

An Initial Candidate for an In-Space Assembly Mission: The Starshade

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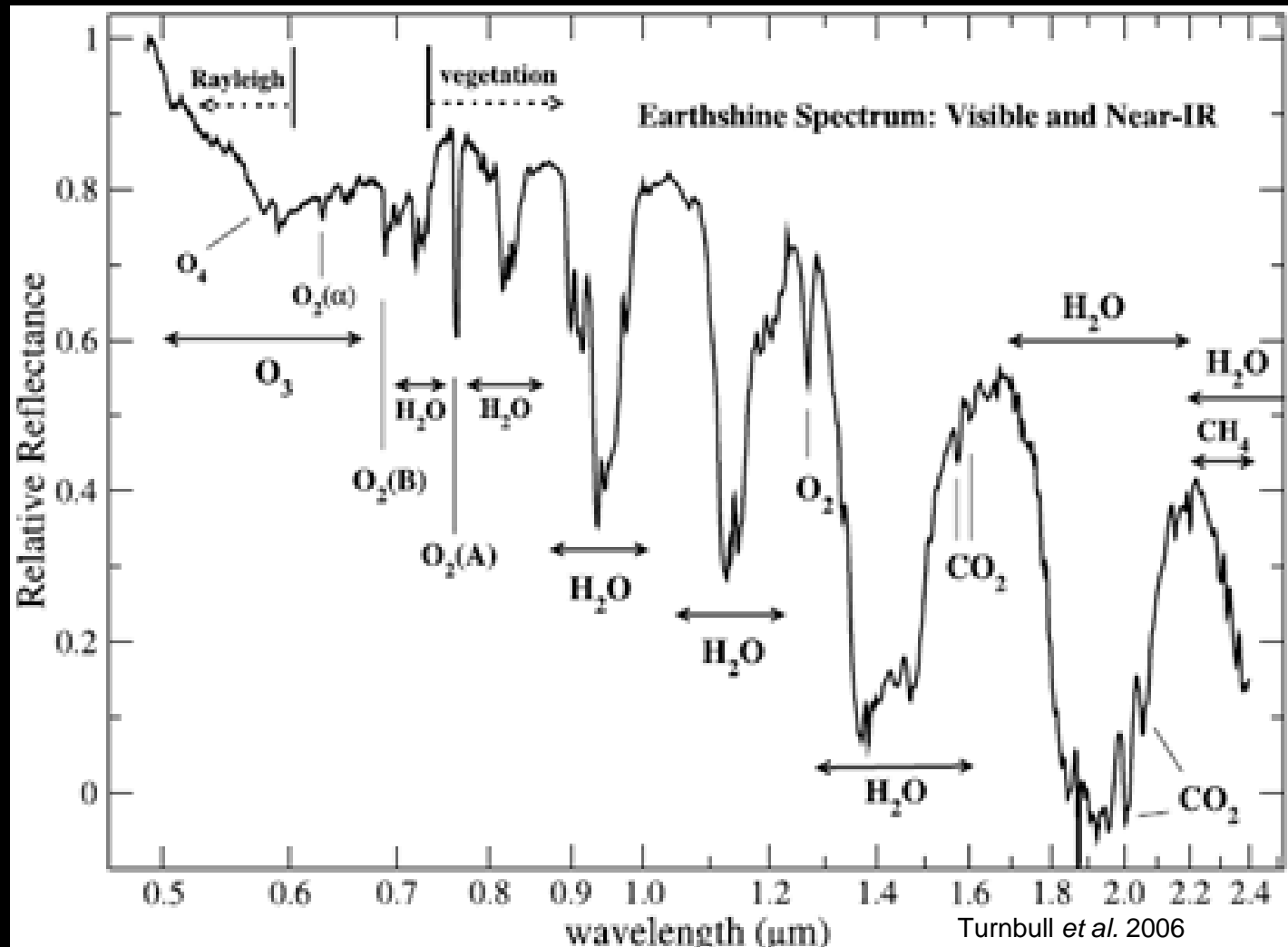
Science & Exploration Directorate
Astrophysicist
NASA GSFC

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In-Space Servicing and Assembly TIM GSFC

The decision to implement a Starshade mission will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

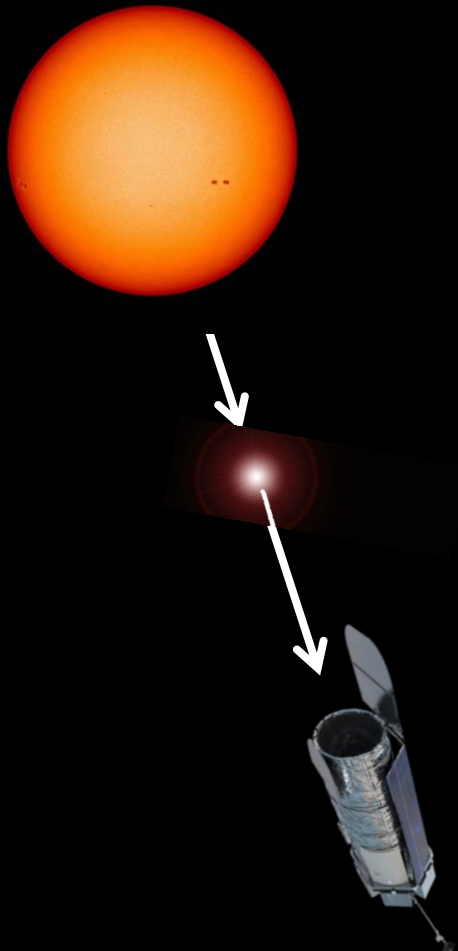
The Evidence for Life on Exoplanets

Spectroscopy (aka Biosignatures)

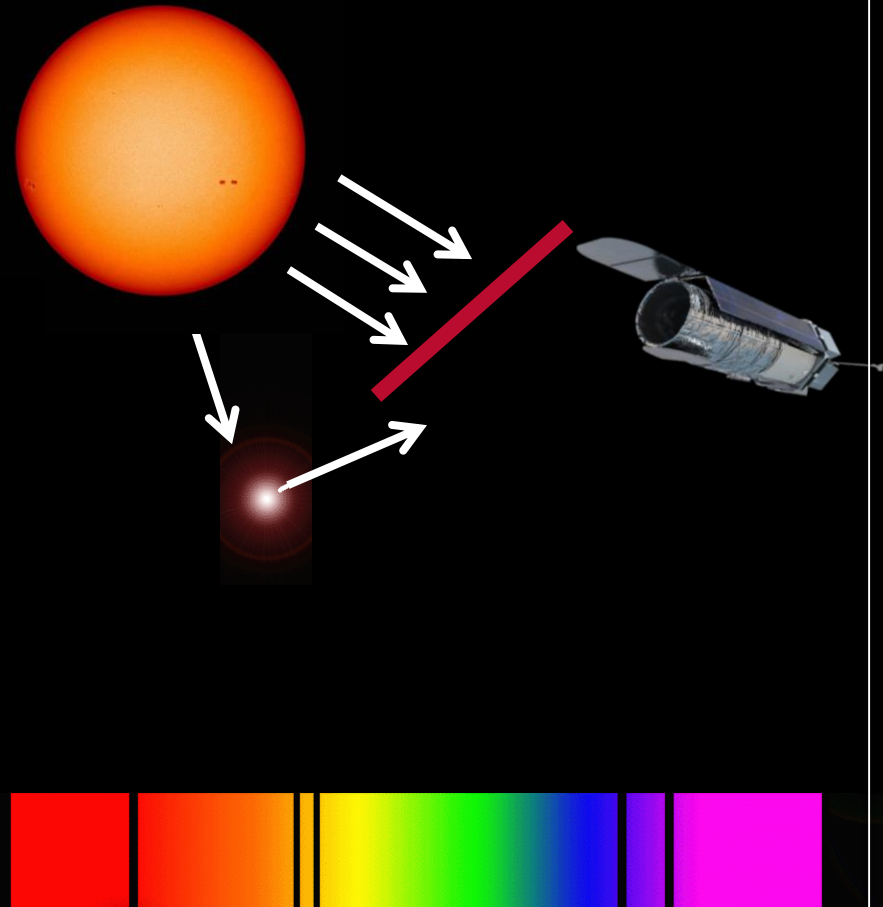


Two Astronomical Types of Spectroscopy

Transmission



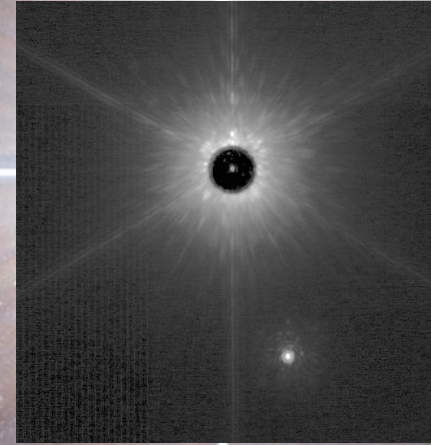
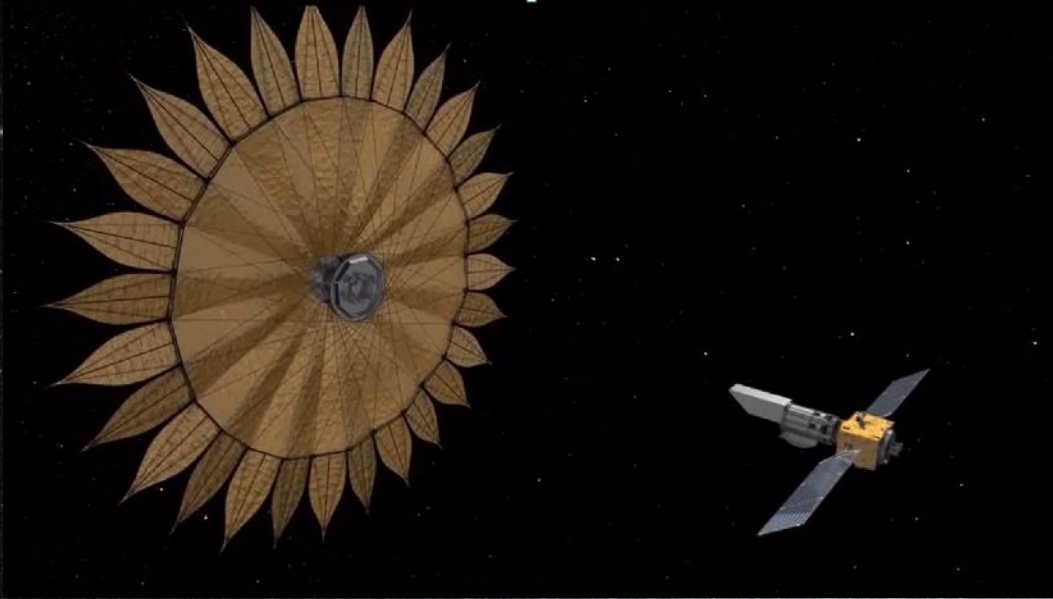
Reflection



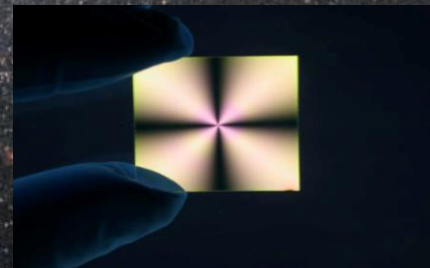
Starlight Suppression

The key capability to search for life on exoplanets

External Occulter (Starshade)

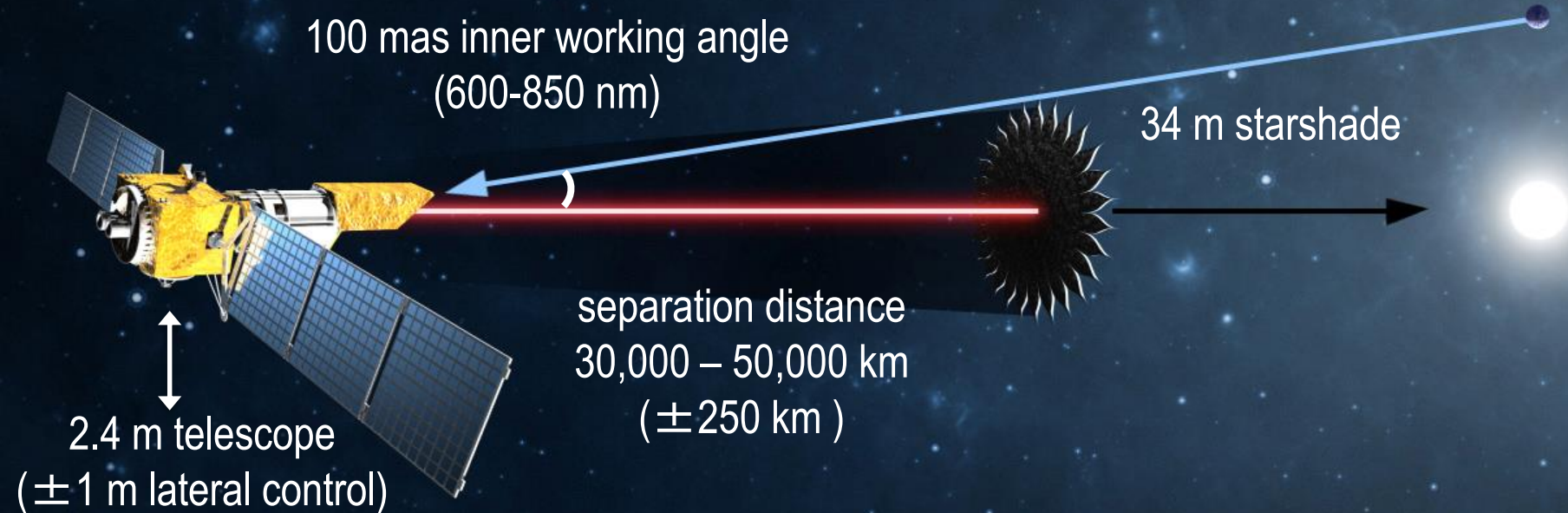


Internal Occulter (Coronagraph)



A Starshade Mission Concept Animation Video

The Case for Large Starshades



- As telescopes get larger, greater throughput, higher spectral resolution
- As telescopes get larger, starshades get larger and farther away
- As starshades get larger, their inner working angles get smaller
- As inner working angles get smaller, telescopes can probe for more Earth-sized planets in the habitable zones of their stars

Early Optical Performance Demonstration

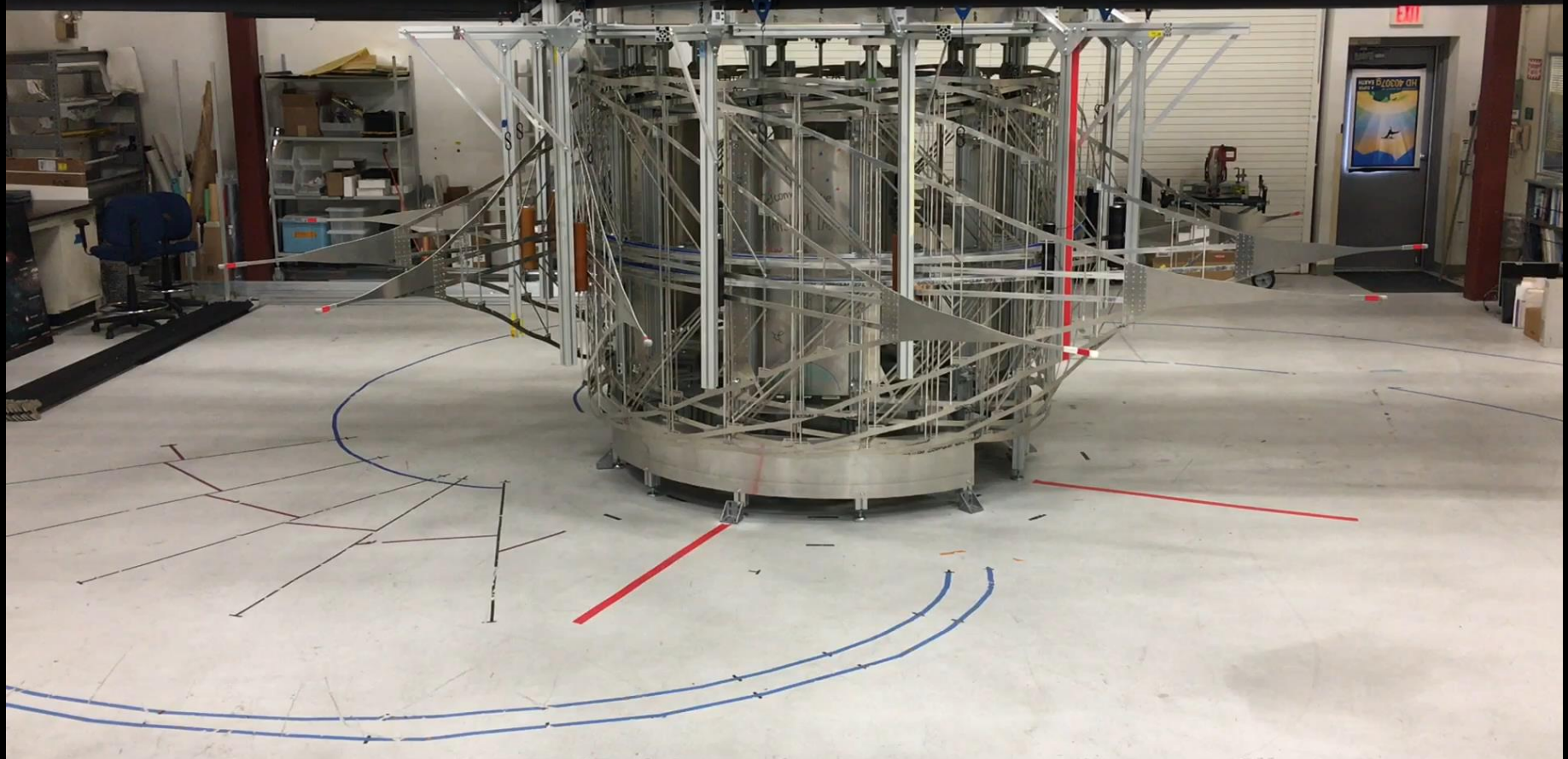
50 cm prototype separated 1 km from telescope

simulated planet 100
million times fainter than
simulated star



Petal Unfurler Testbed 2.0

10 m prototype



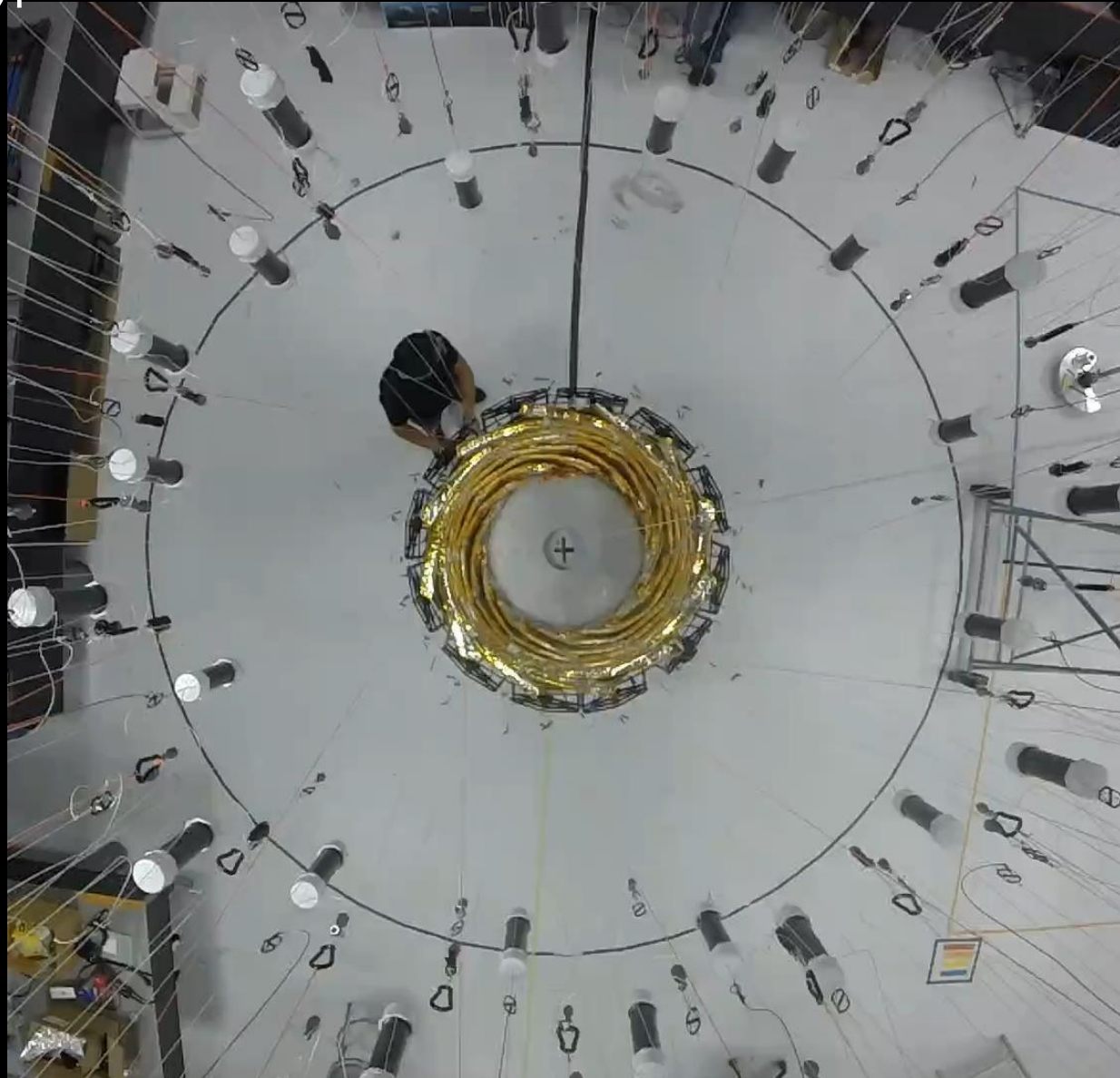
Early Inner Disk Deployment Trials

10 m prototype

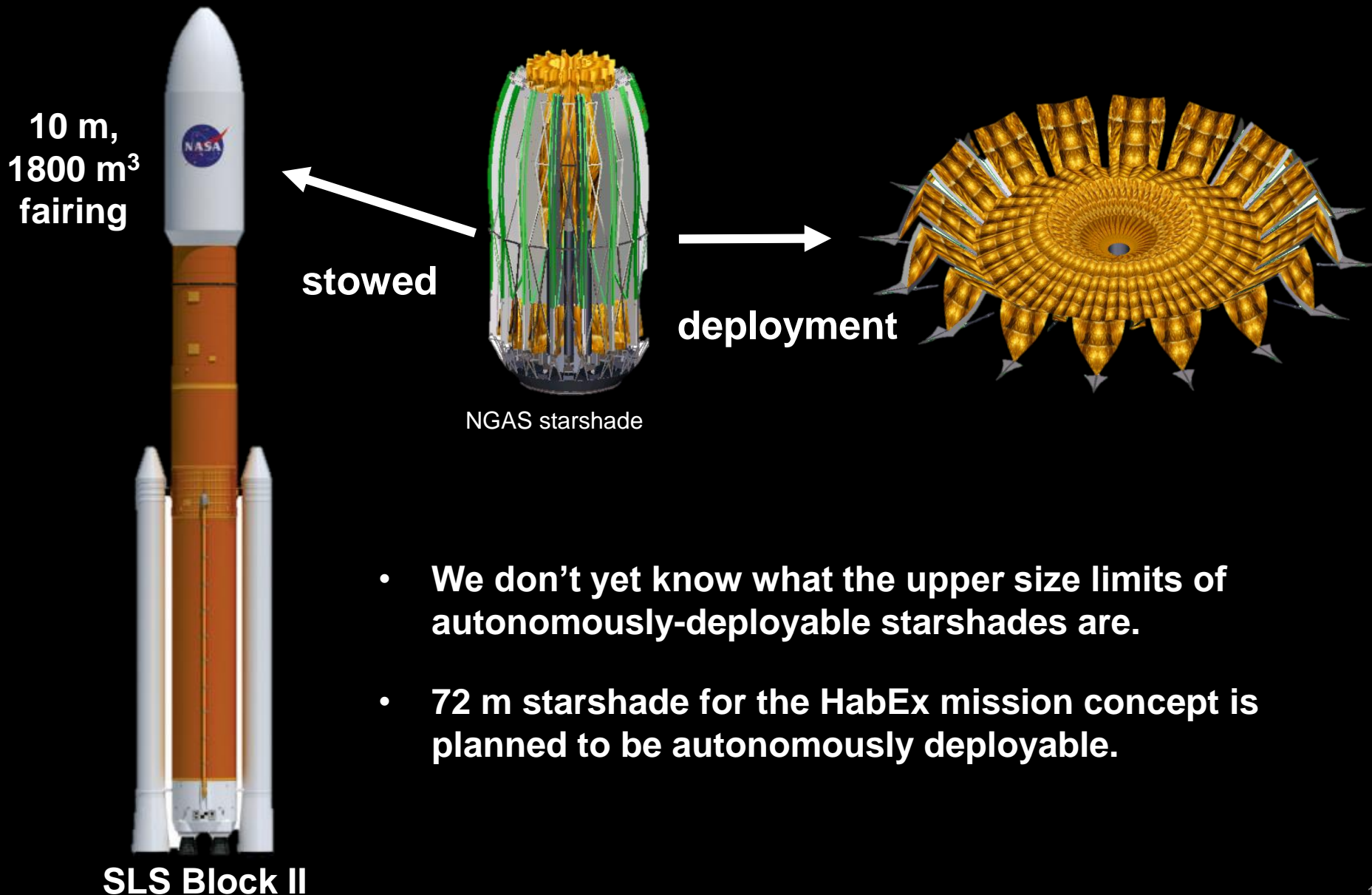


Optical Shield Deployment

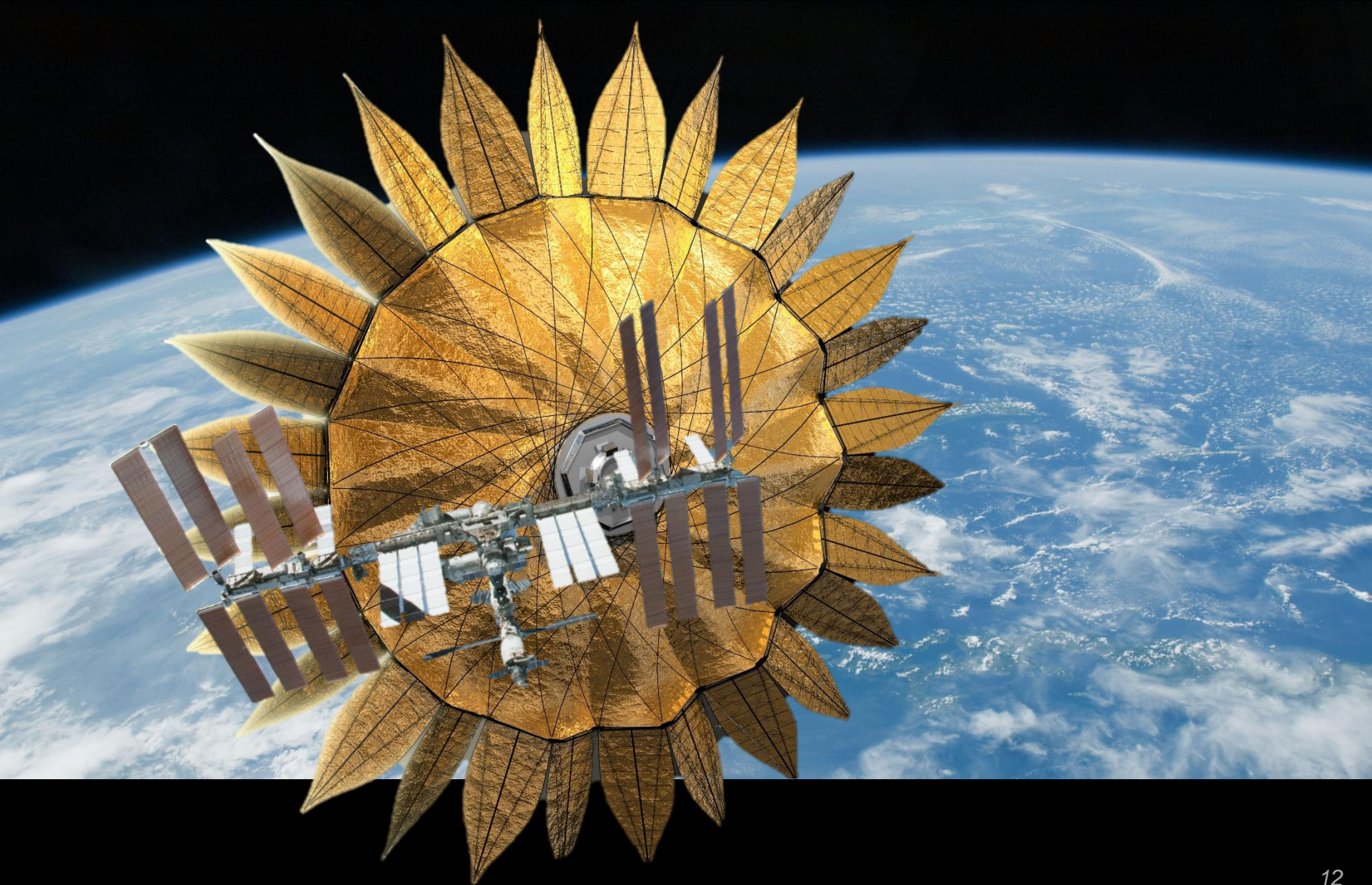
5 m Prototype



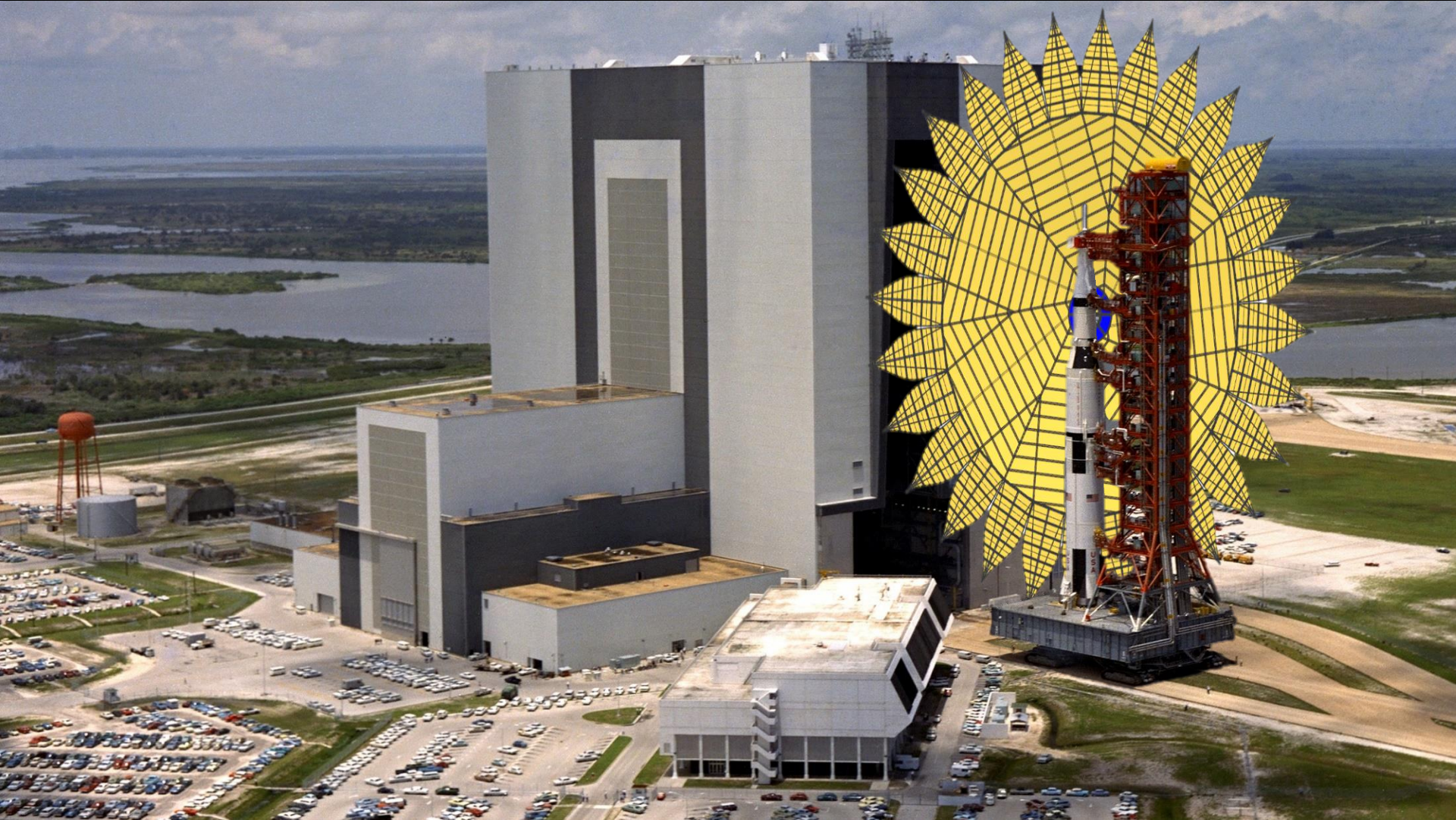
A Limit to Autonomous Deployment



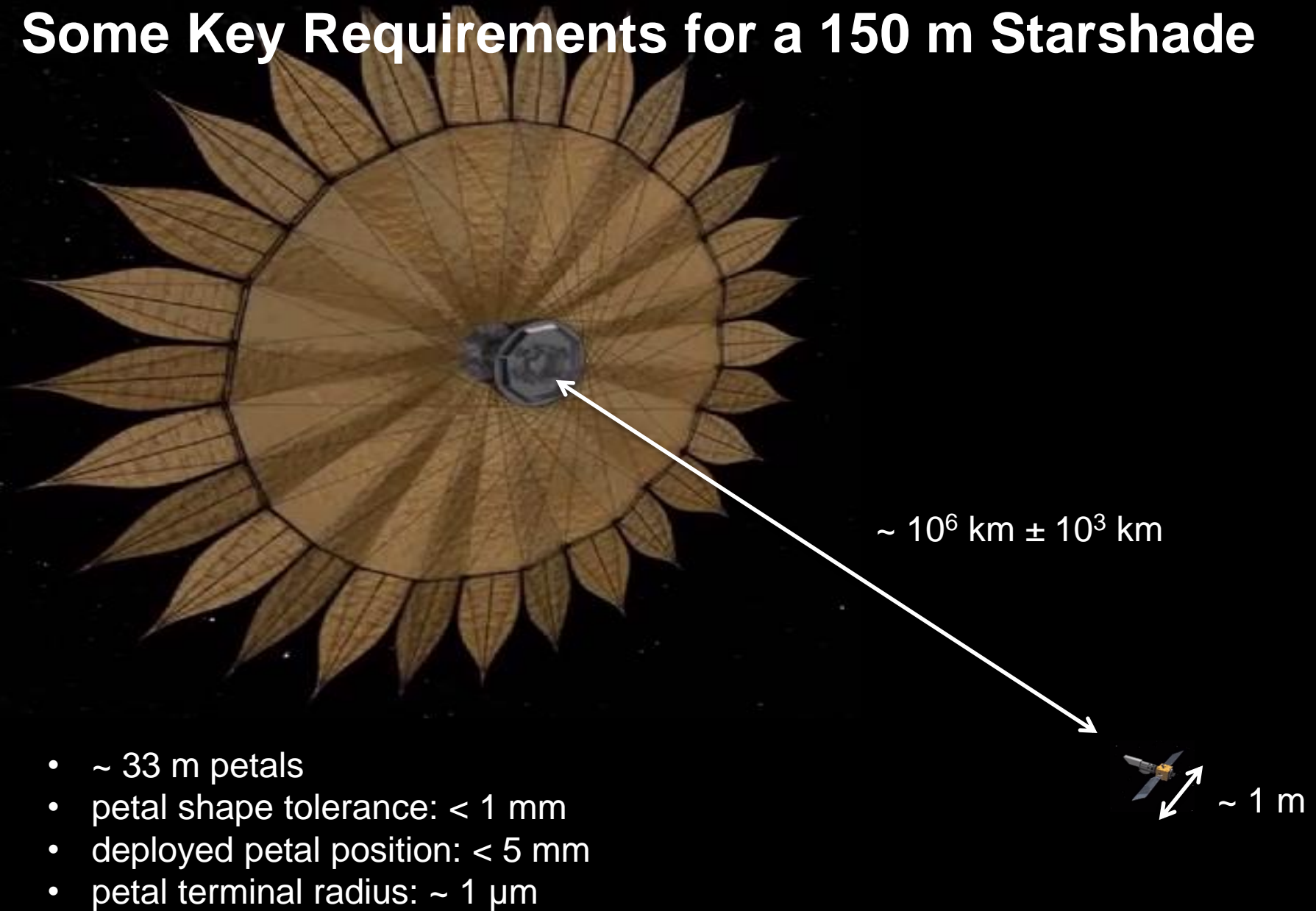
A 150 m Starshade



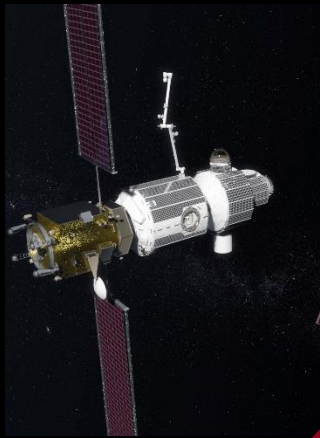
A 150 m Starshade



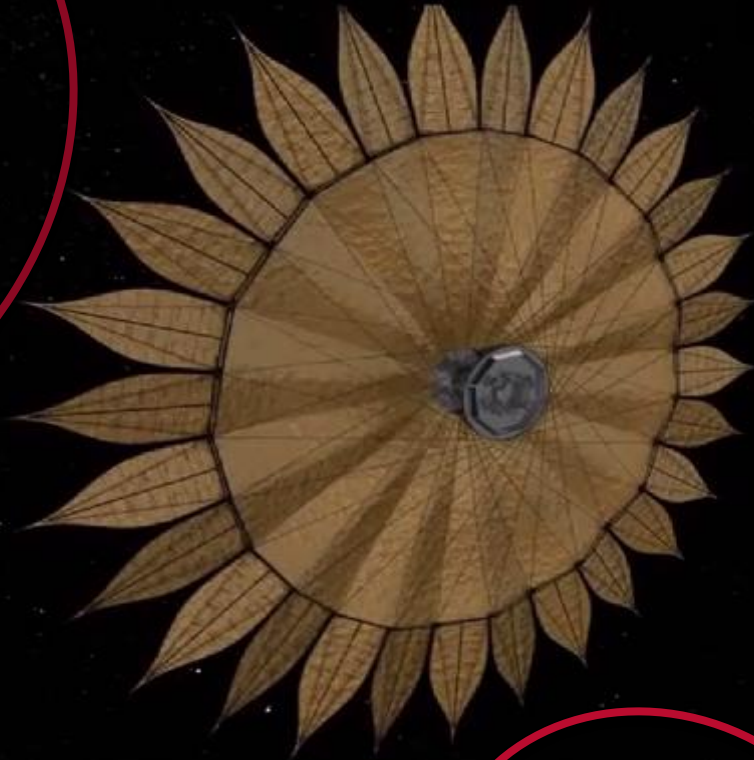
Some Key Requirements for a 150 m Starshade



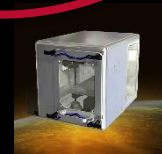
Large Solution Space for In-Space Assembly



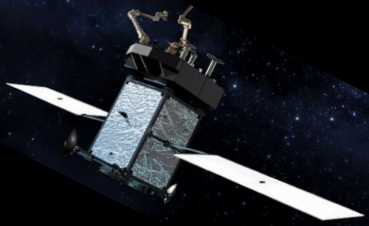
Cis-lunar
station



Starshade
spacecraft bus



In-space
manufacturing



Free-flying
servicer



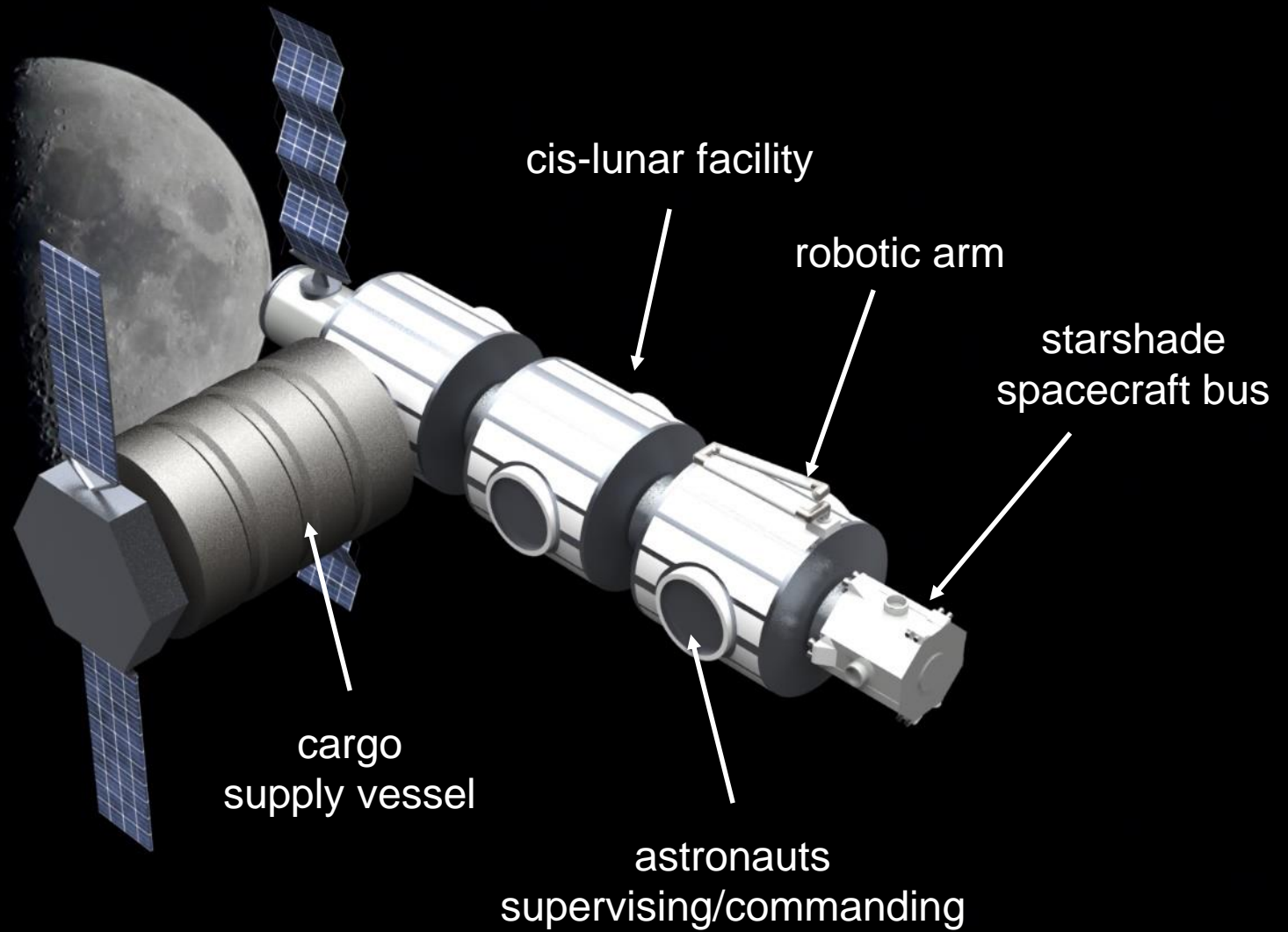
Mobile assembly
robot



Fixed assembly
robot

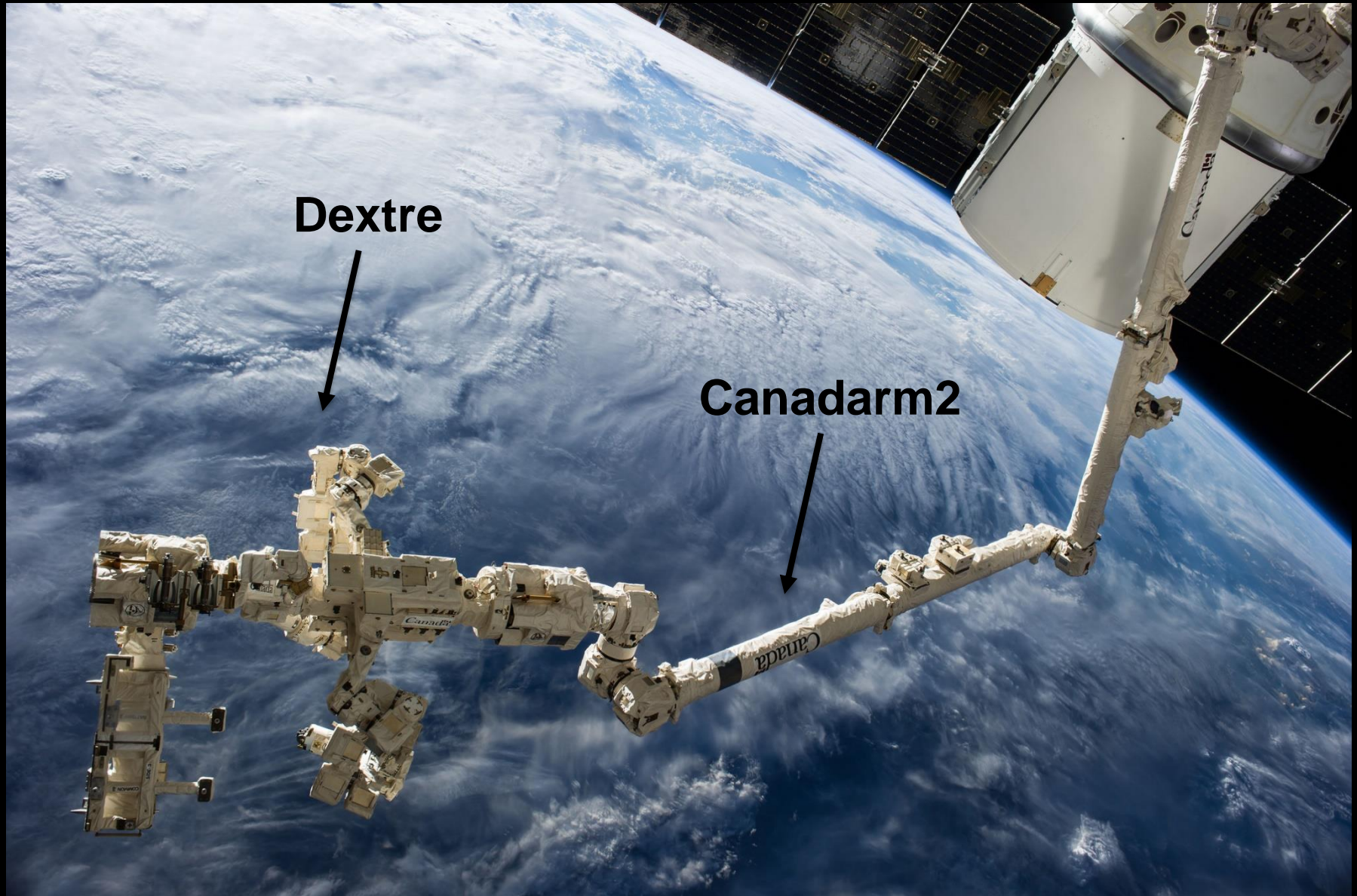


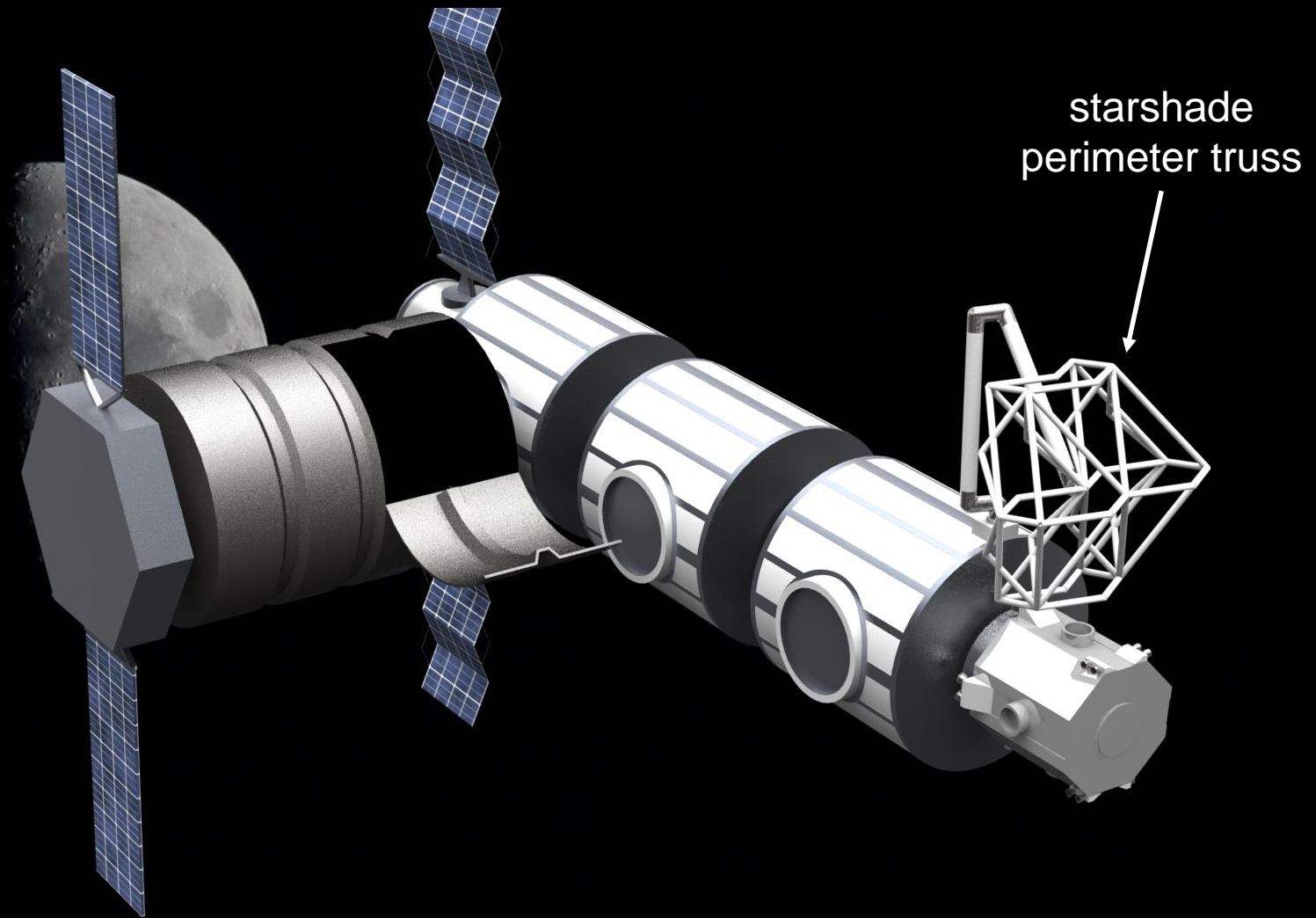
Astronaut
support

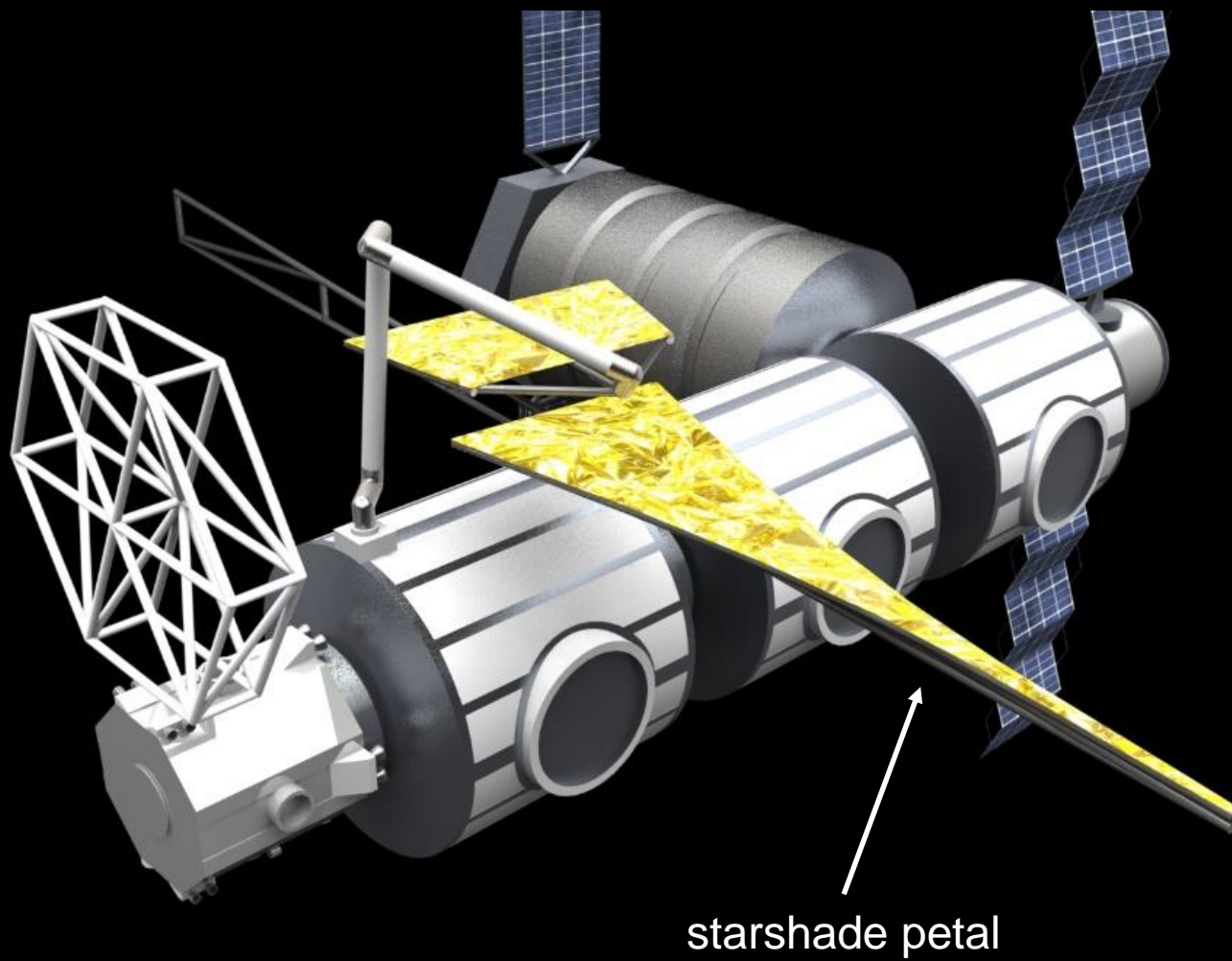


Special Purpose Dexterous Manipulator

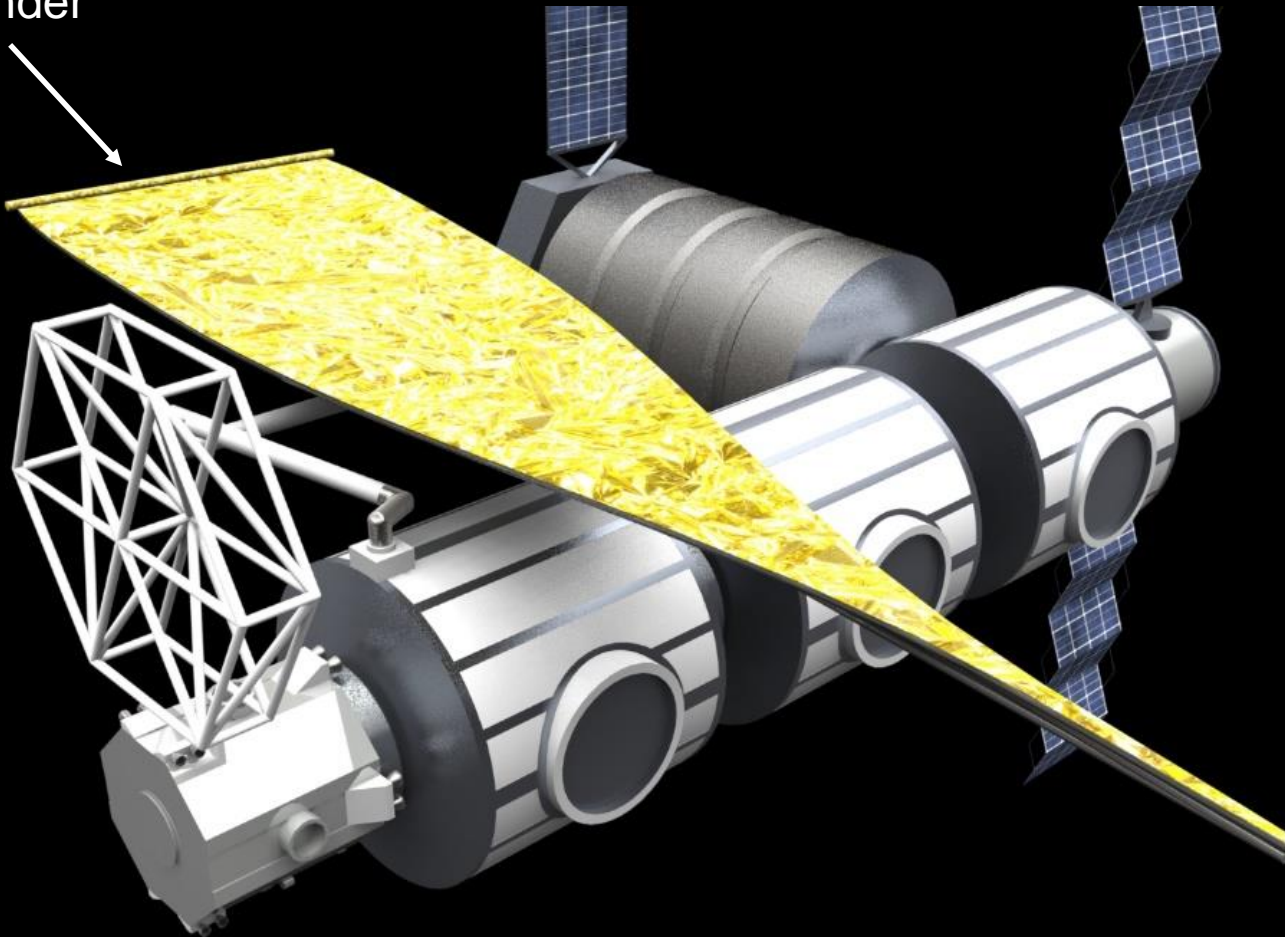
Two armed robot working with Canadarm

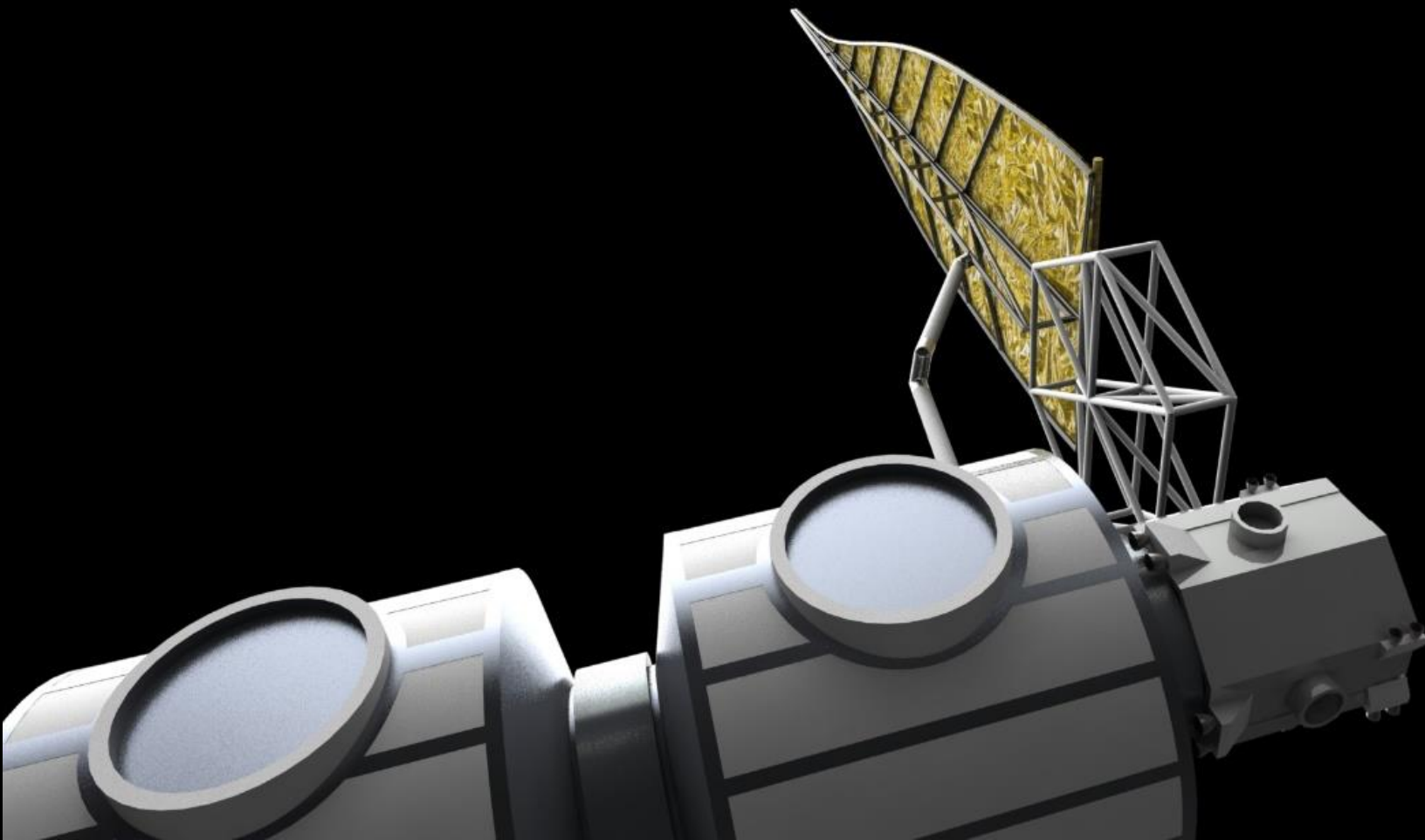


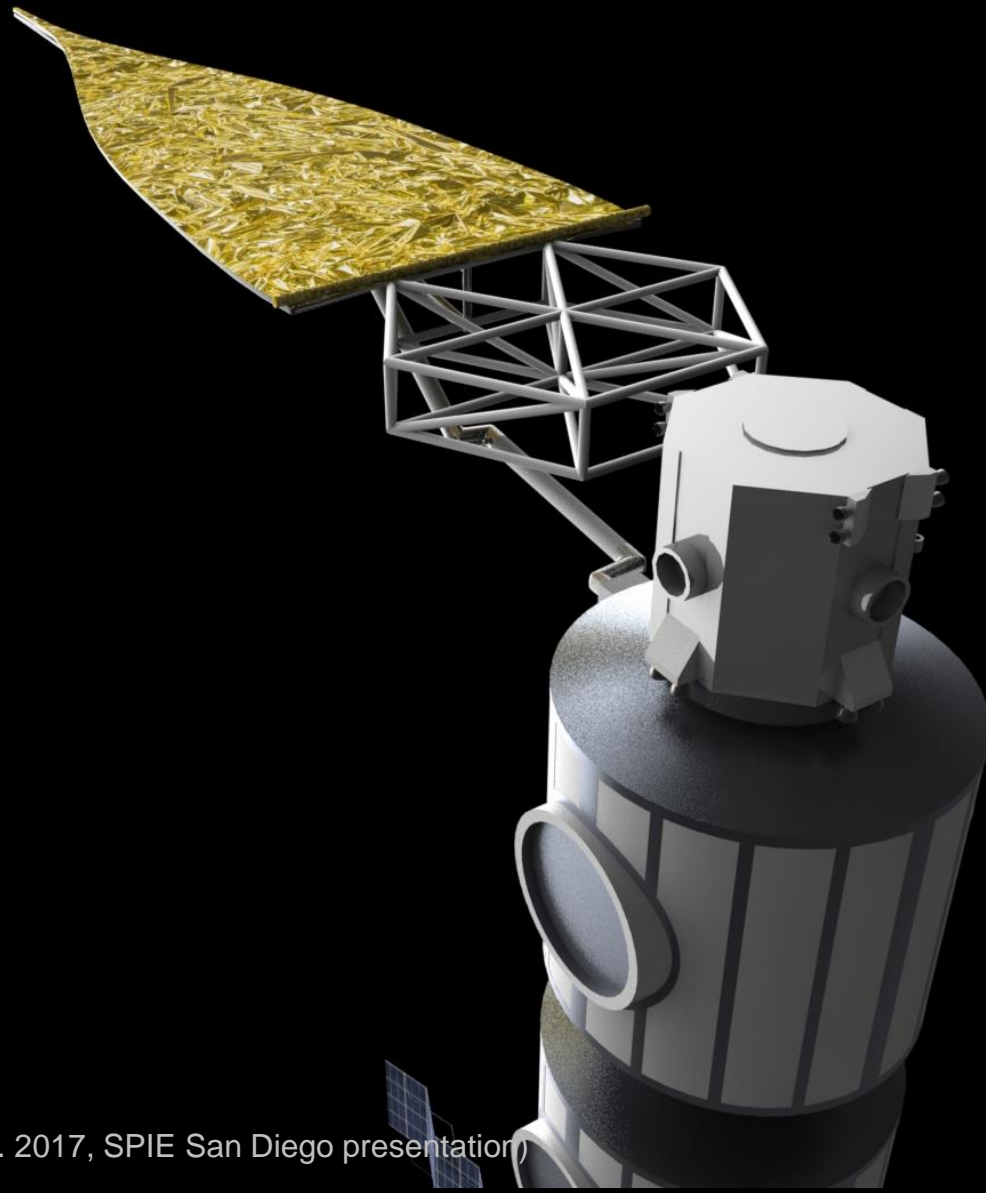




starshade inner
disk cylinder



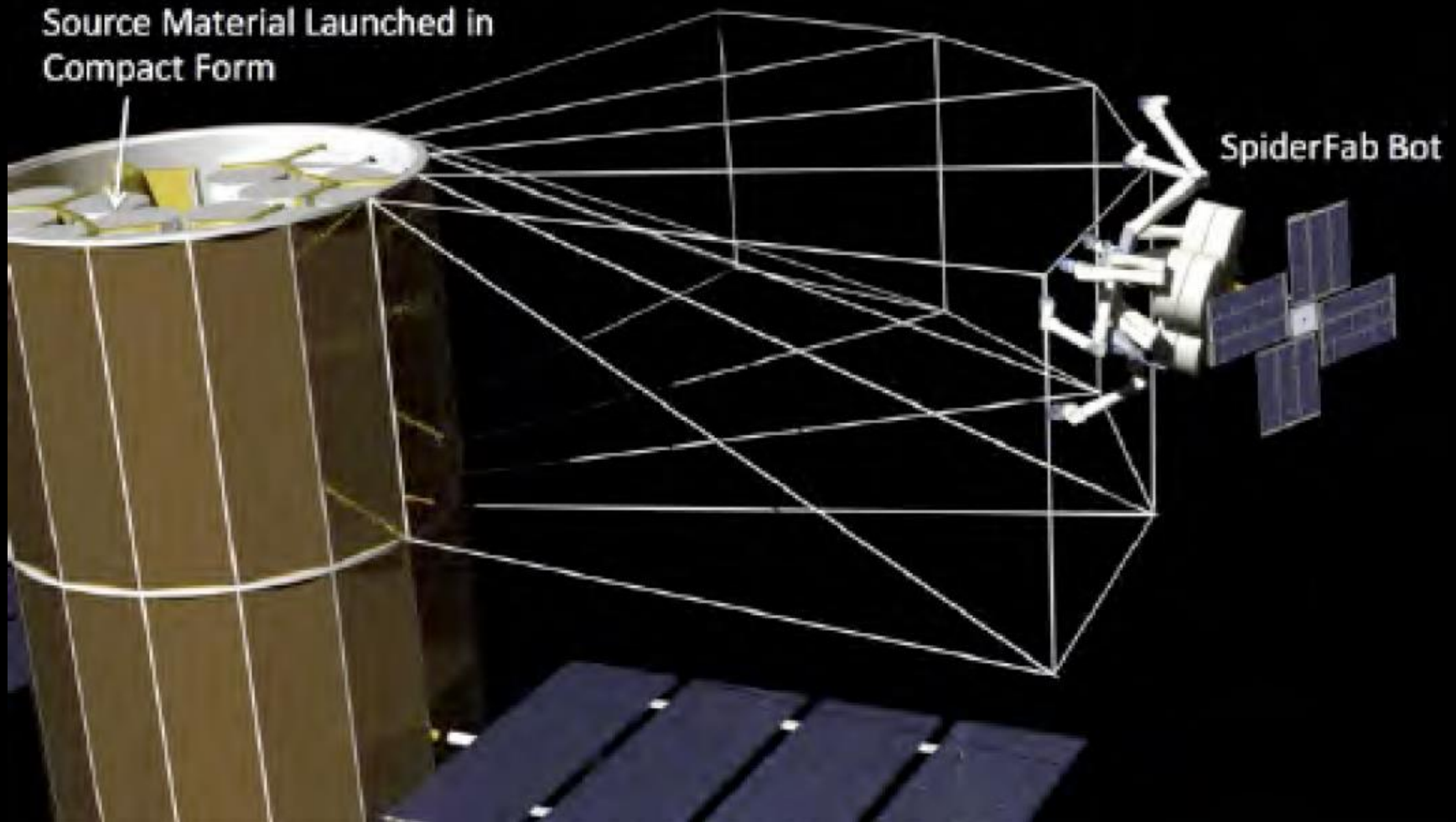


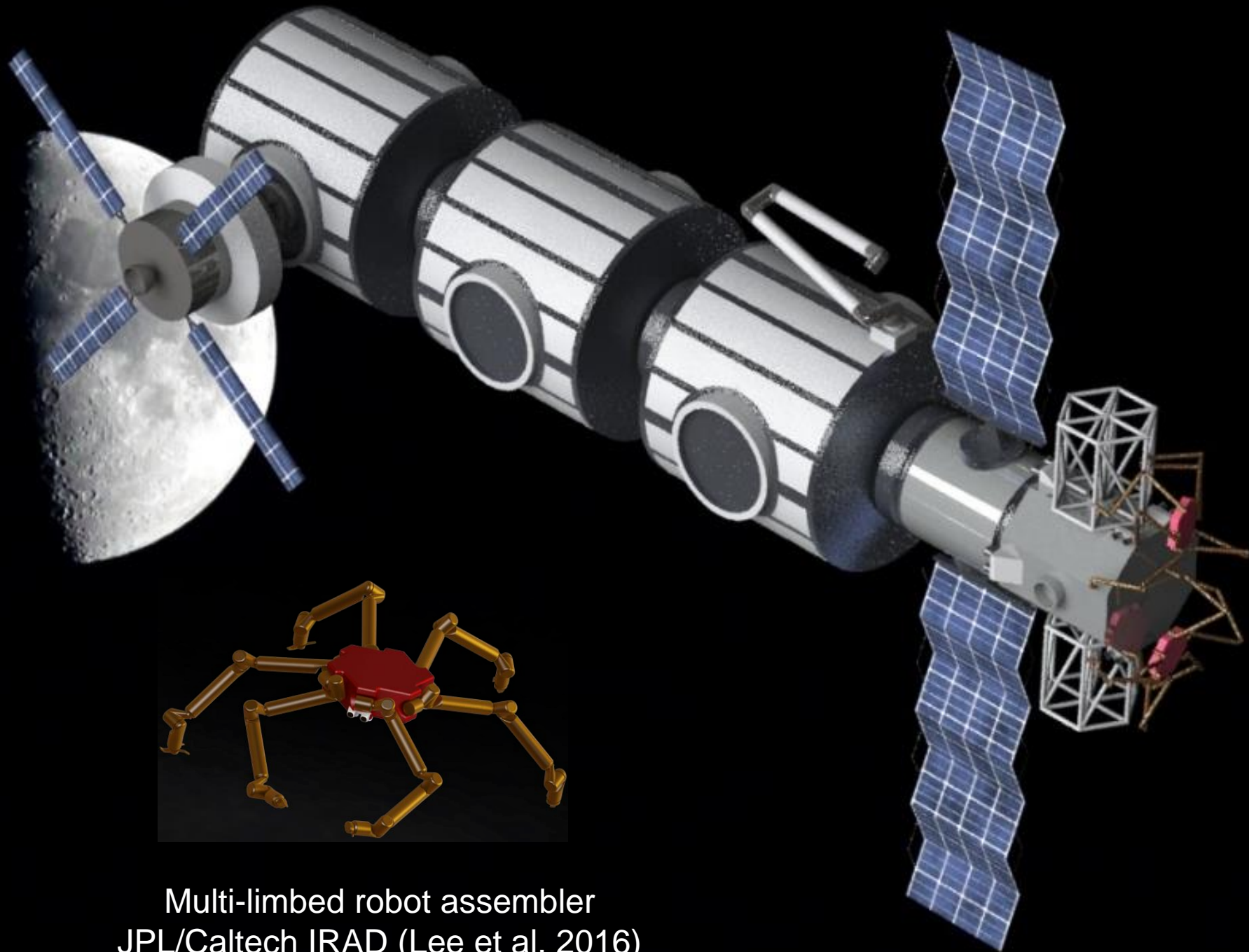




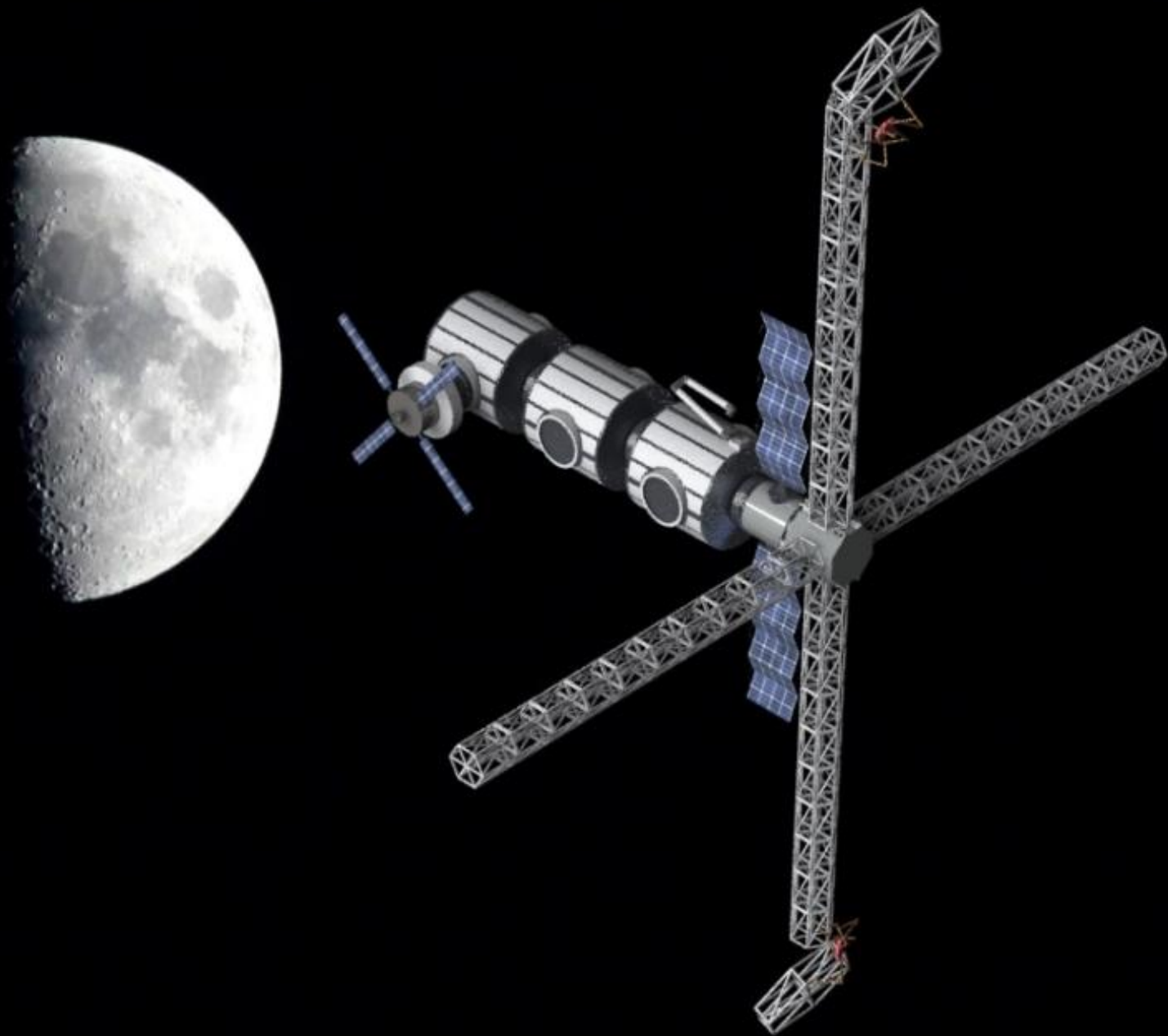
SpiderFab Bot

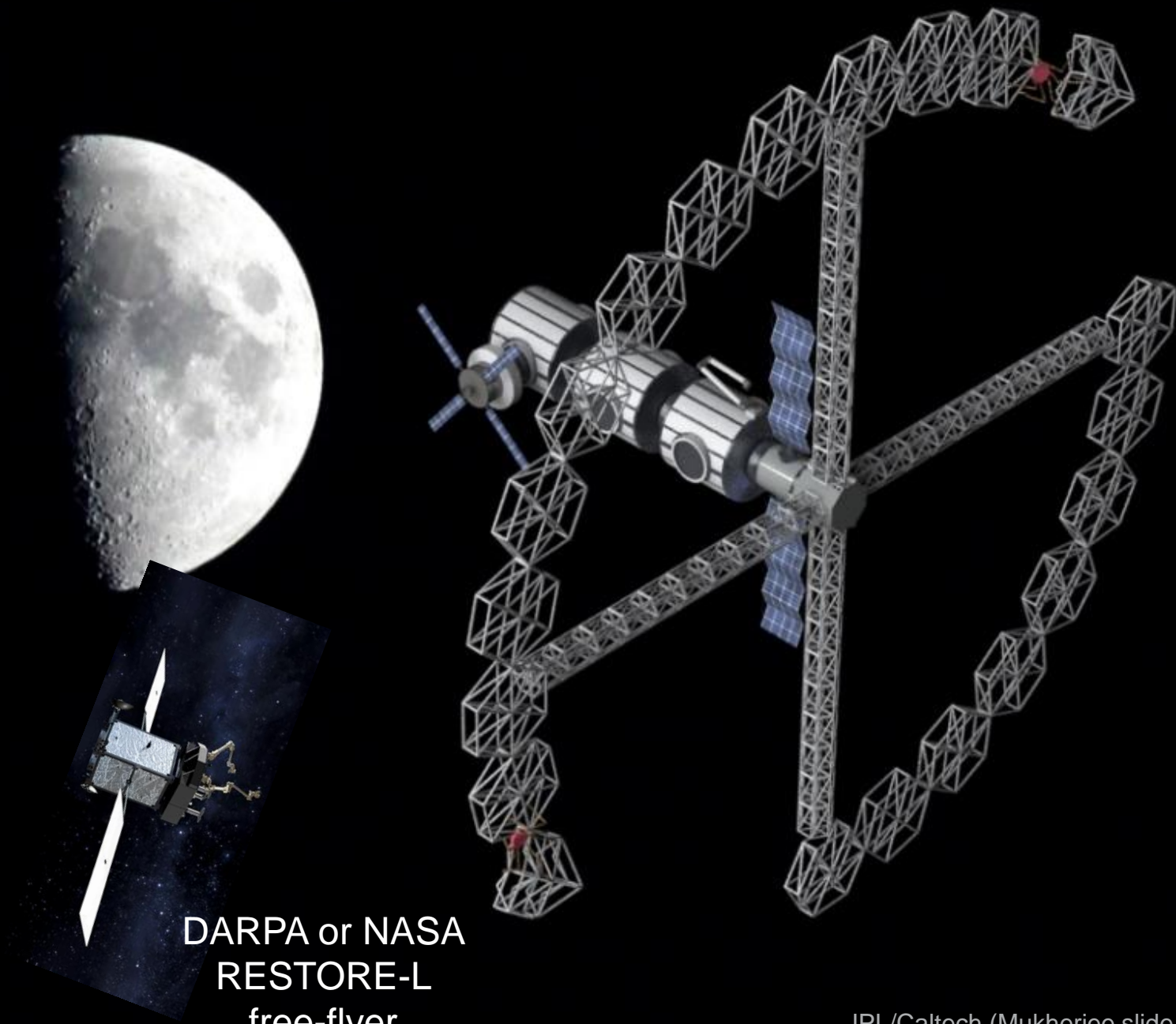
In-Space Manufacturing, Assembly, and Metrology





Multi-limbed robot assembler
JPL/Caltech IRAD (Lee et al. 2016)

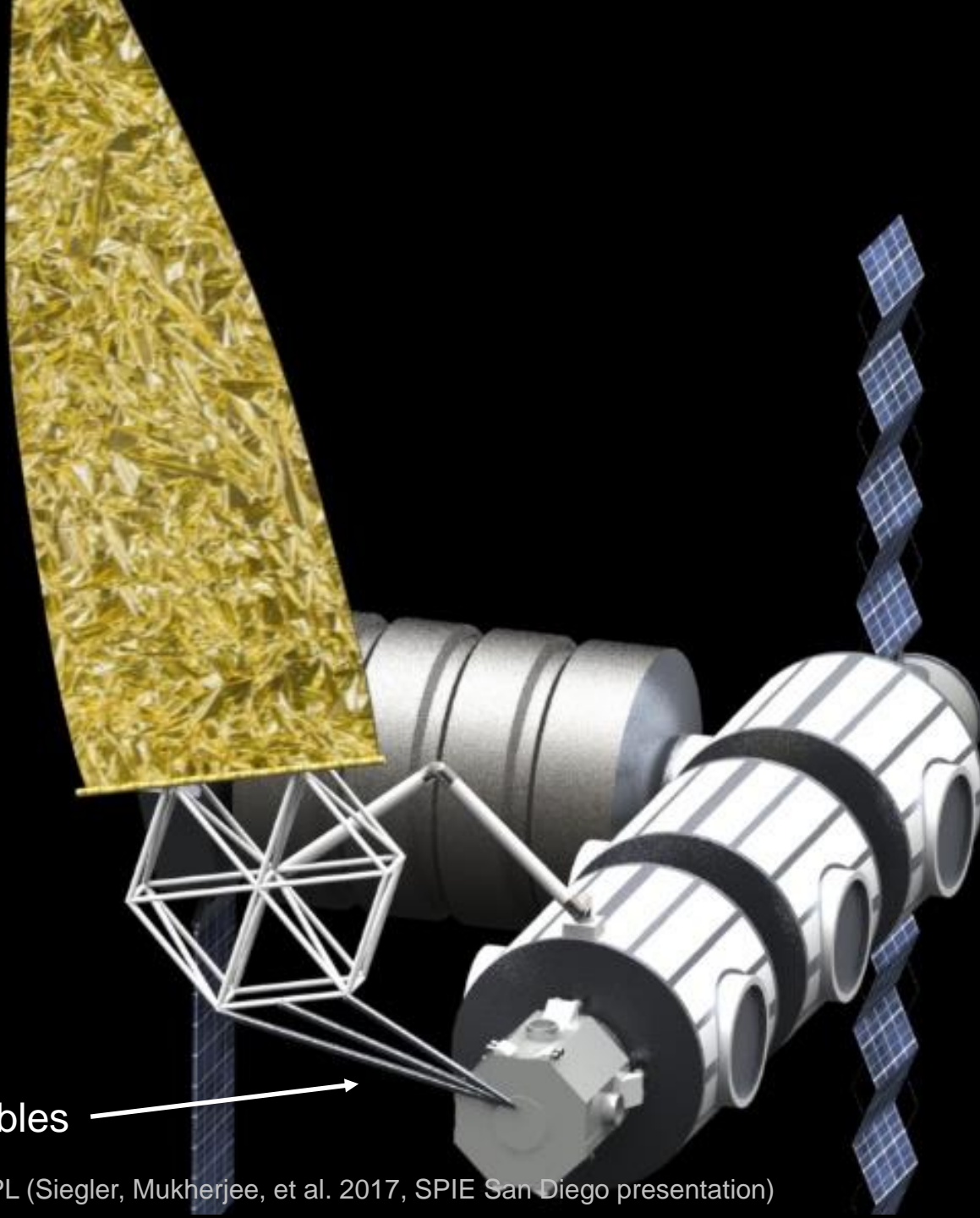


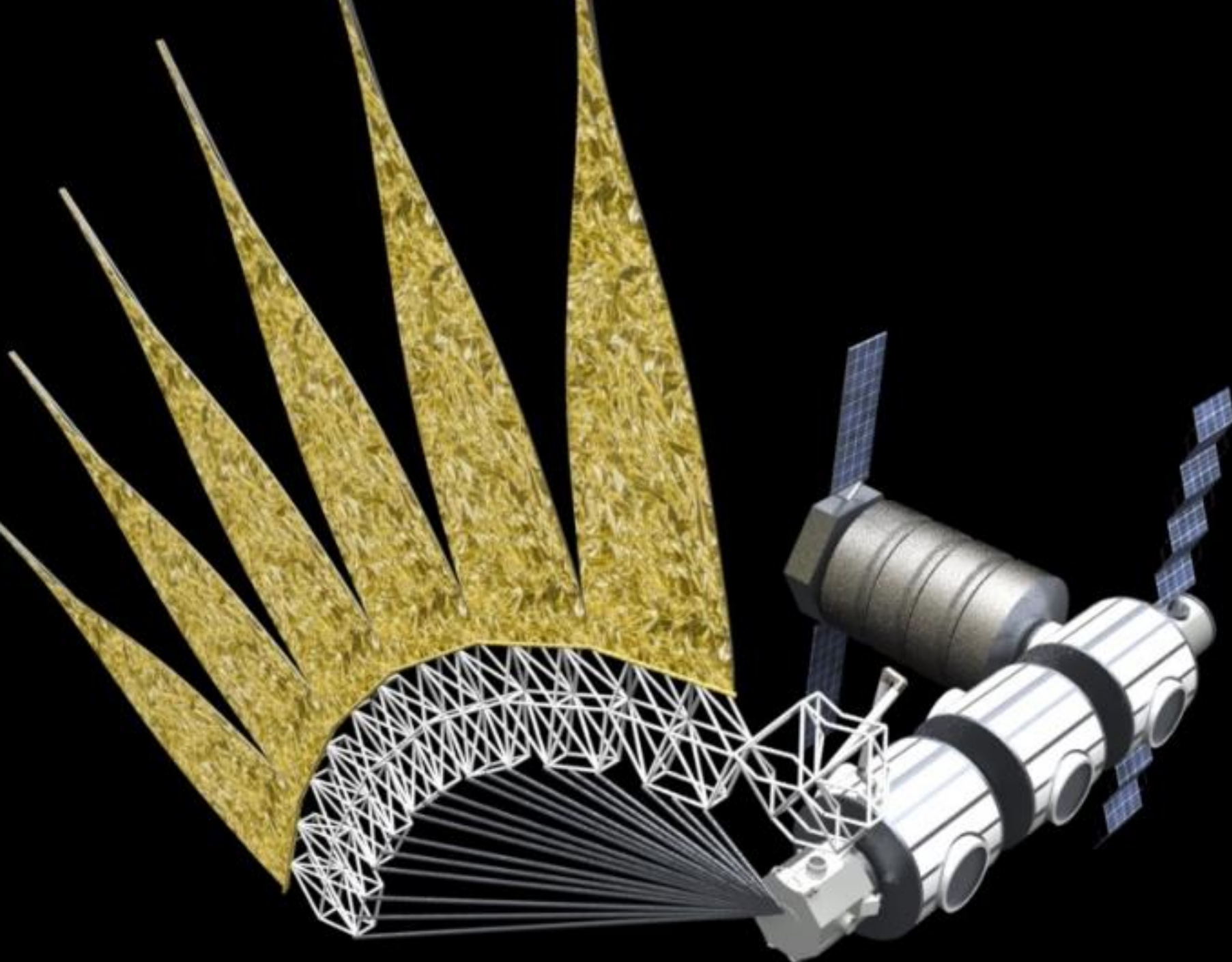


DARPA or NASA
RESTORE-L
free-flyer

steel cables

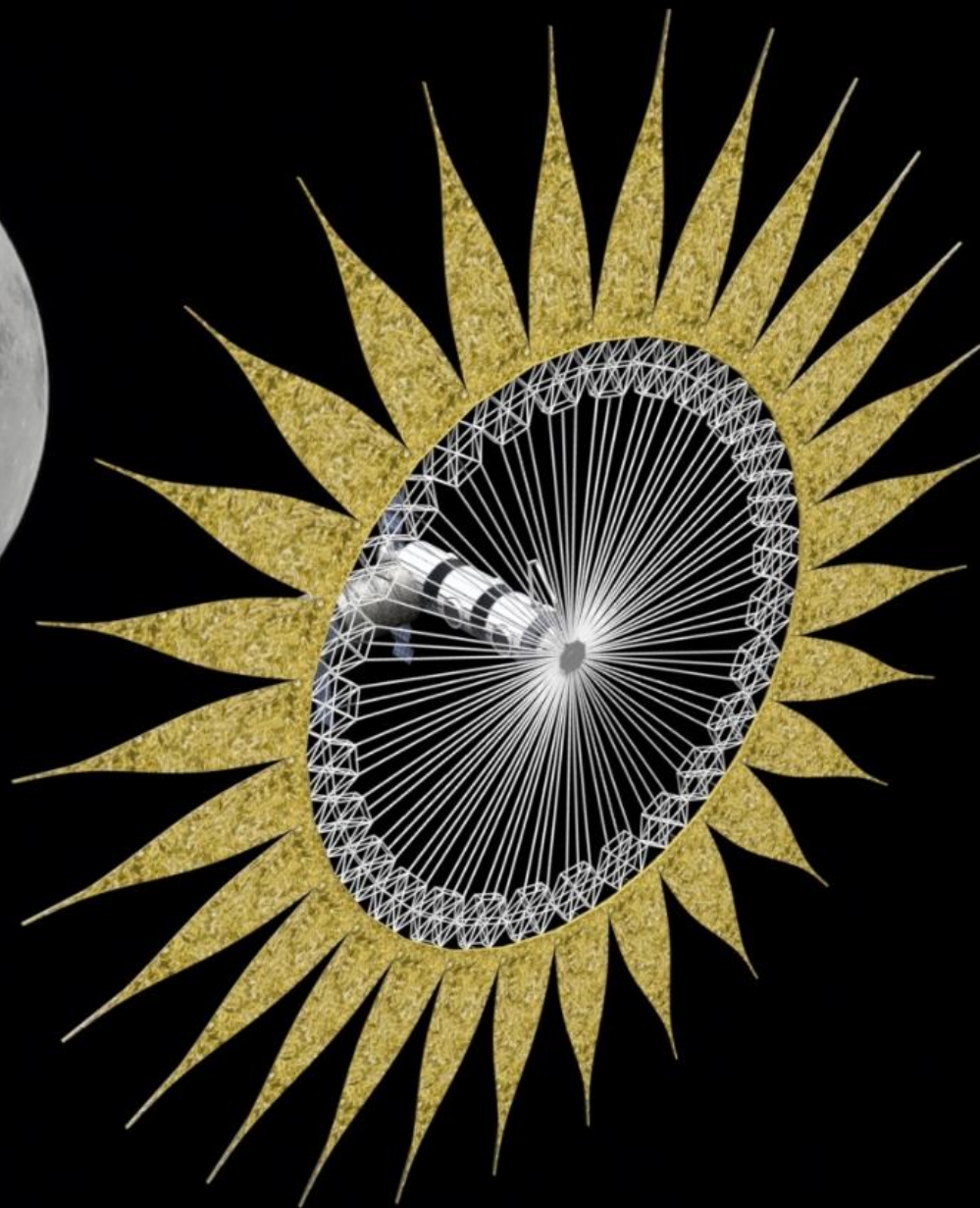
JPL (Siegler, Mukherjee, et al. 2017, SPIE San Diego presentation)

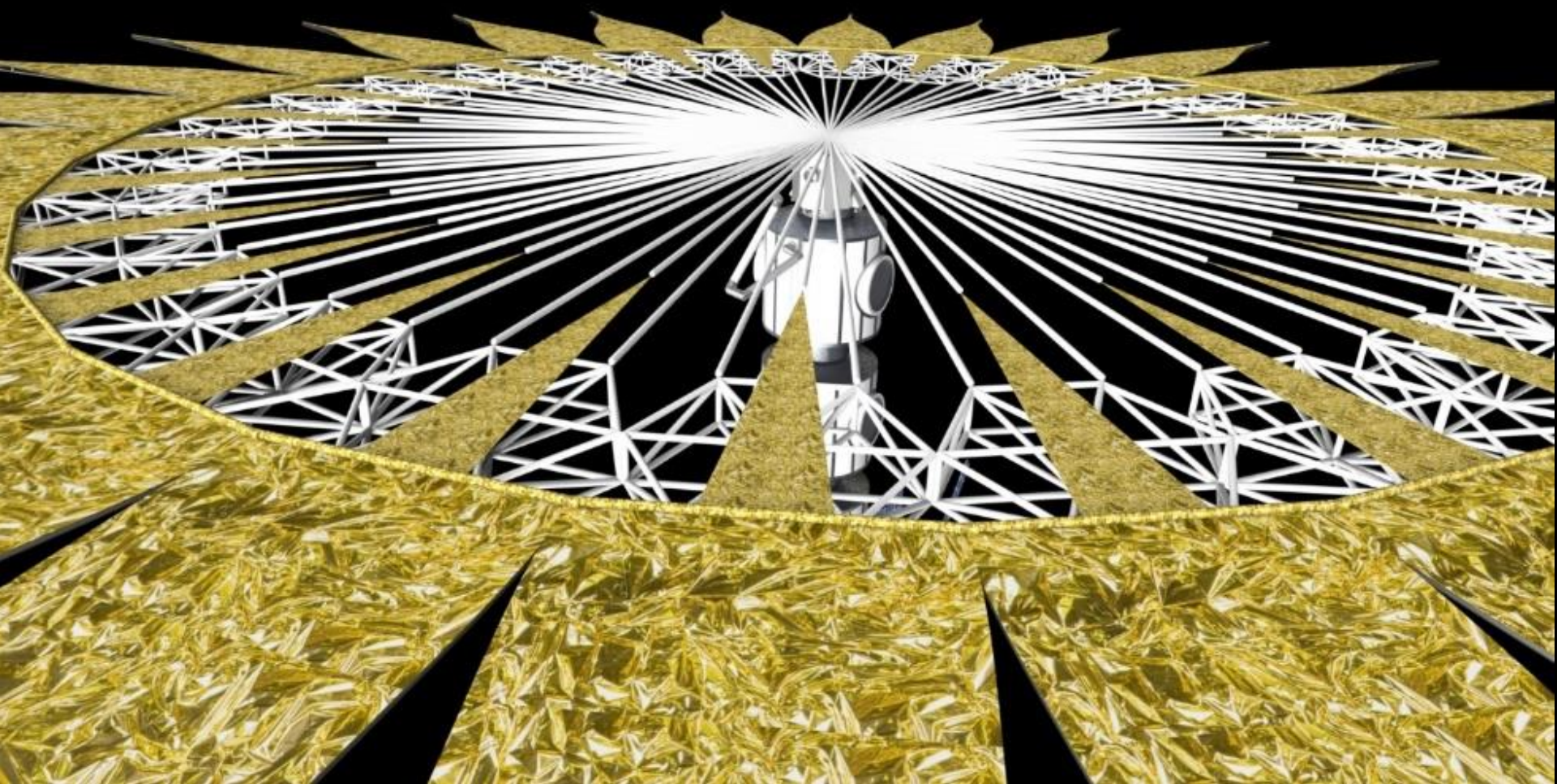


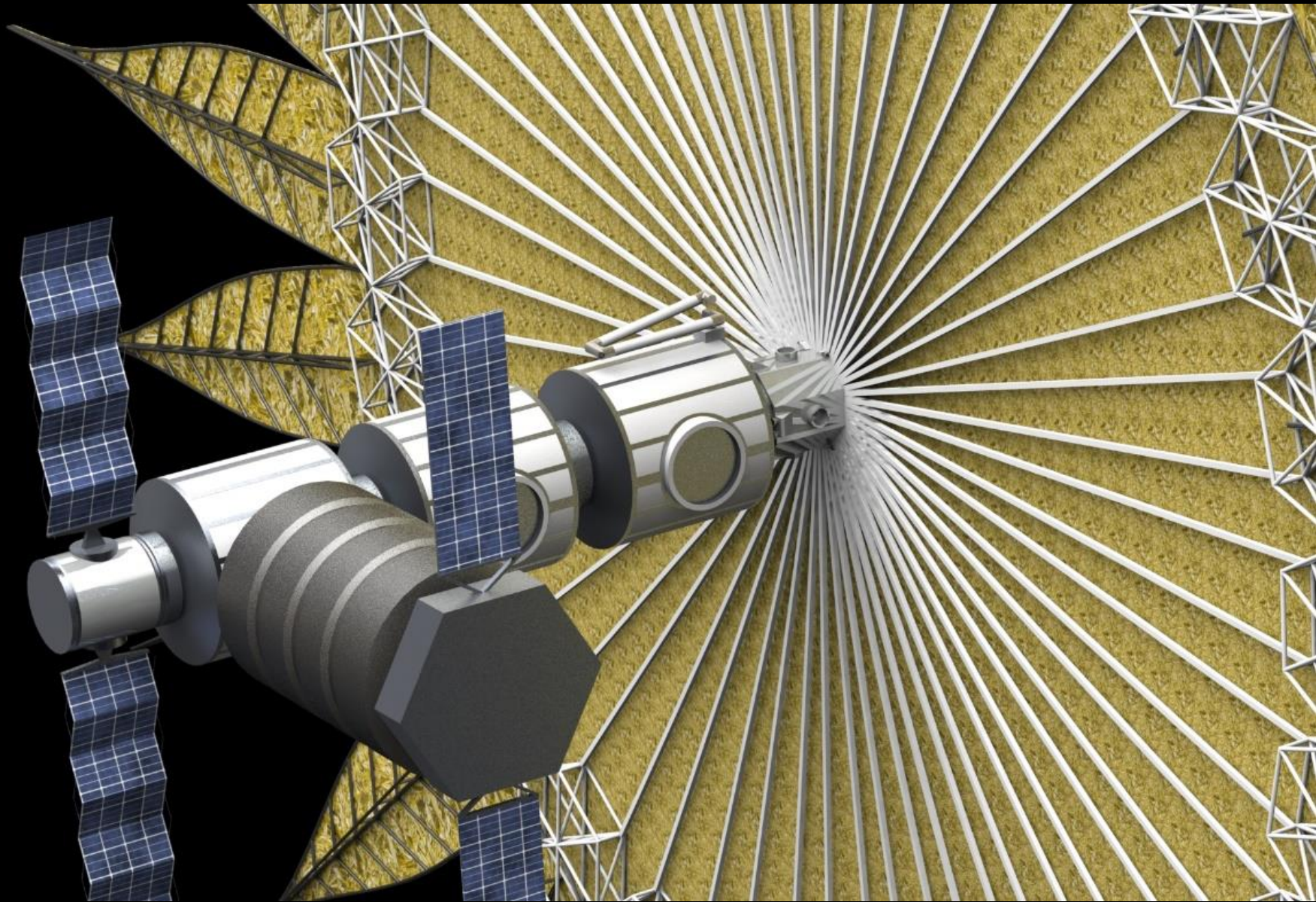


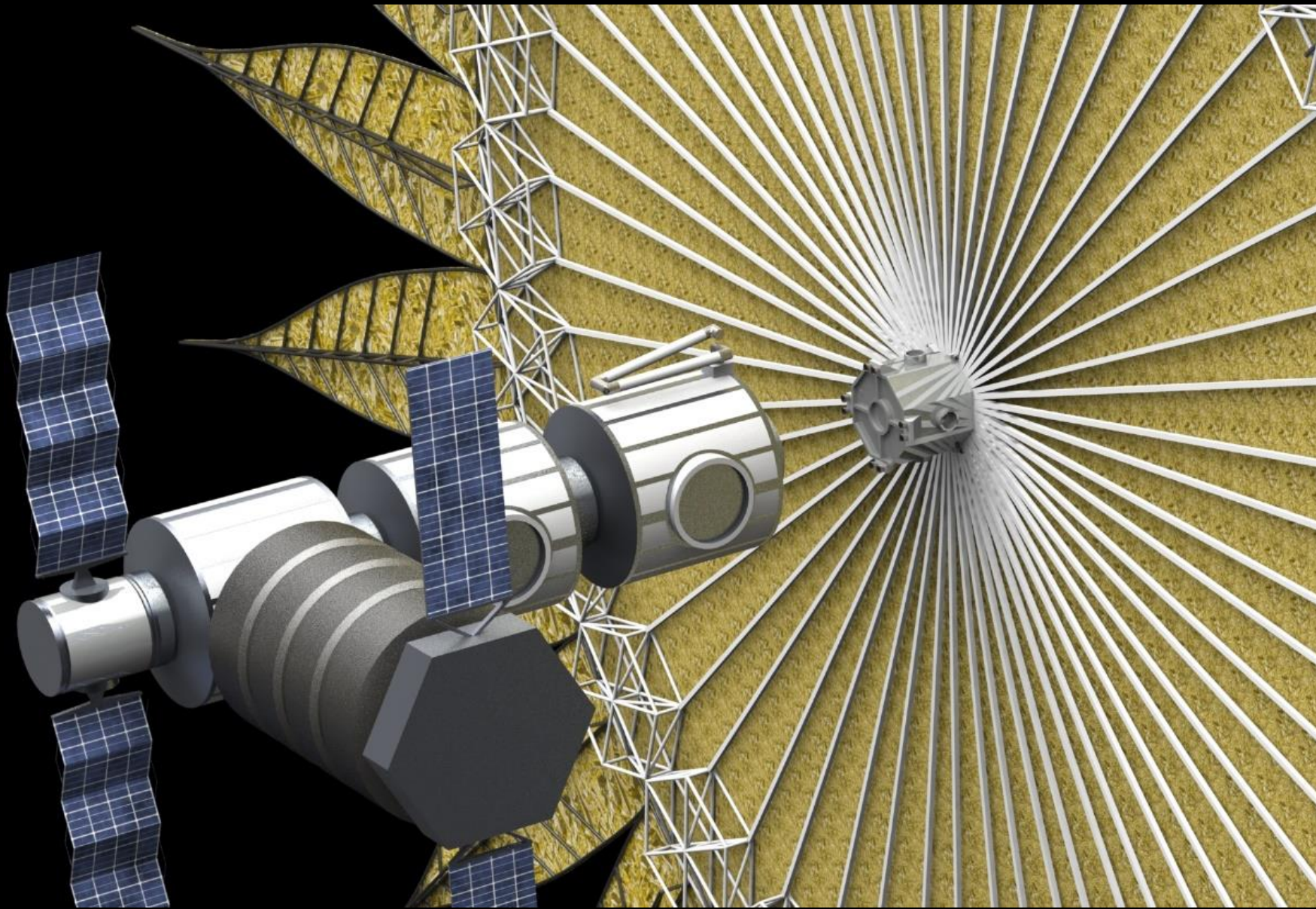
JPL (Sieglar, Mukherjee, et al. 2017, SPIE San Diego presentation)

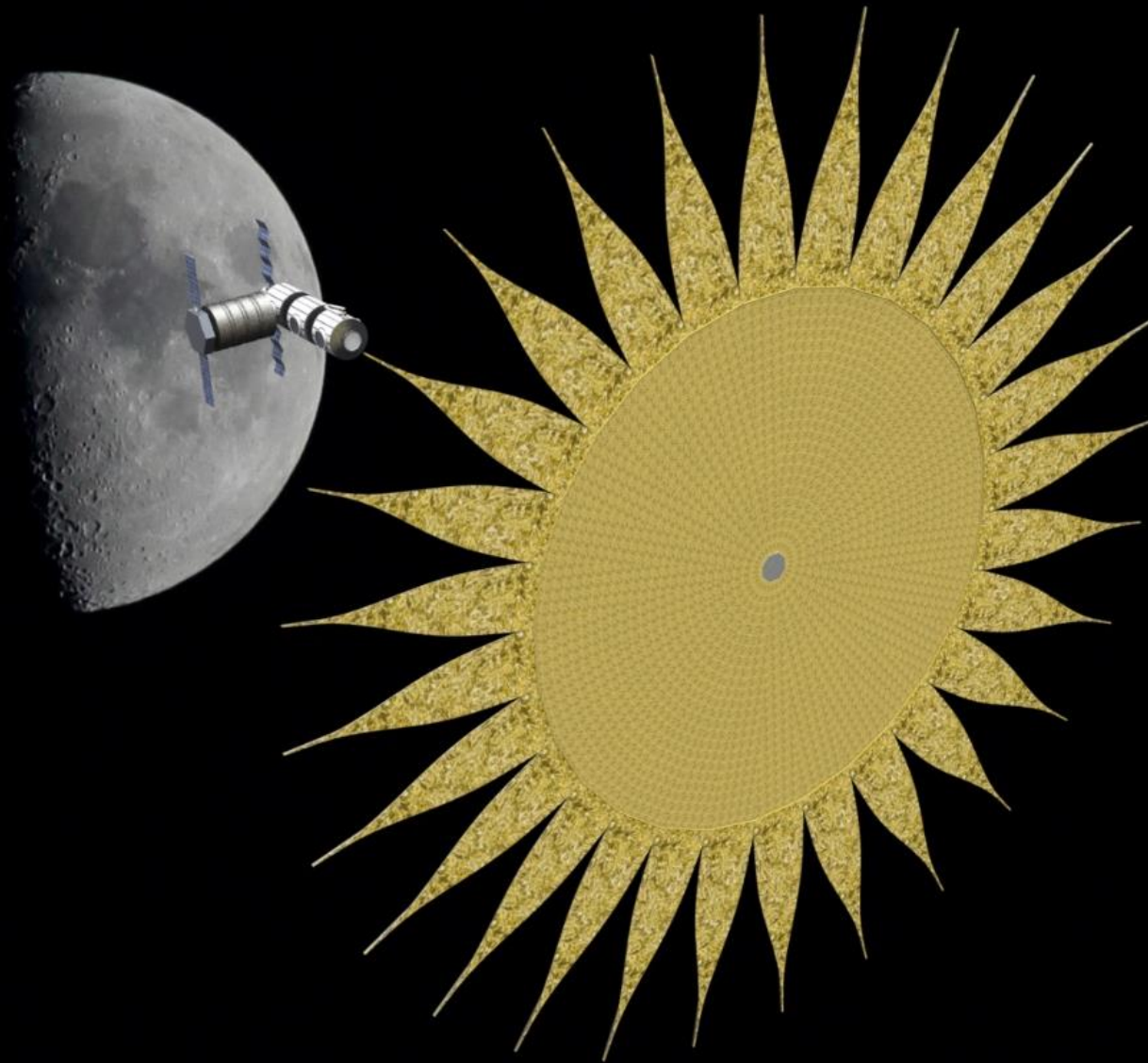












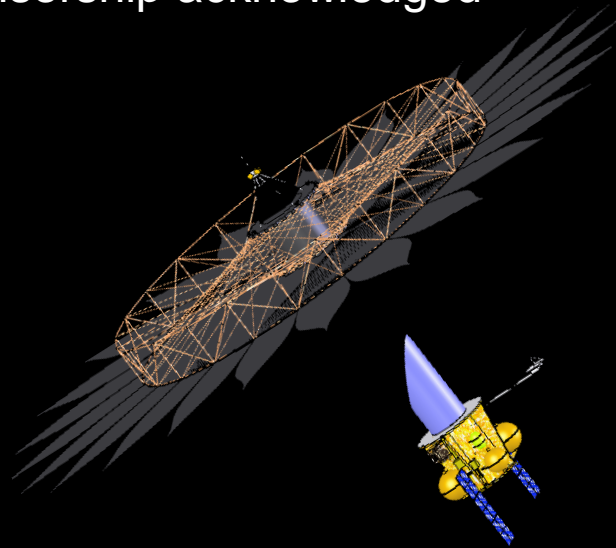
Open questions

- How are the petals and their positions inspected?
- And how are they adjusted or repaired?
- Orbit? Earth-Sun L2?
- Refueling possibilities

Acknowledgements

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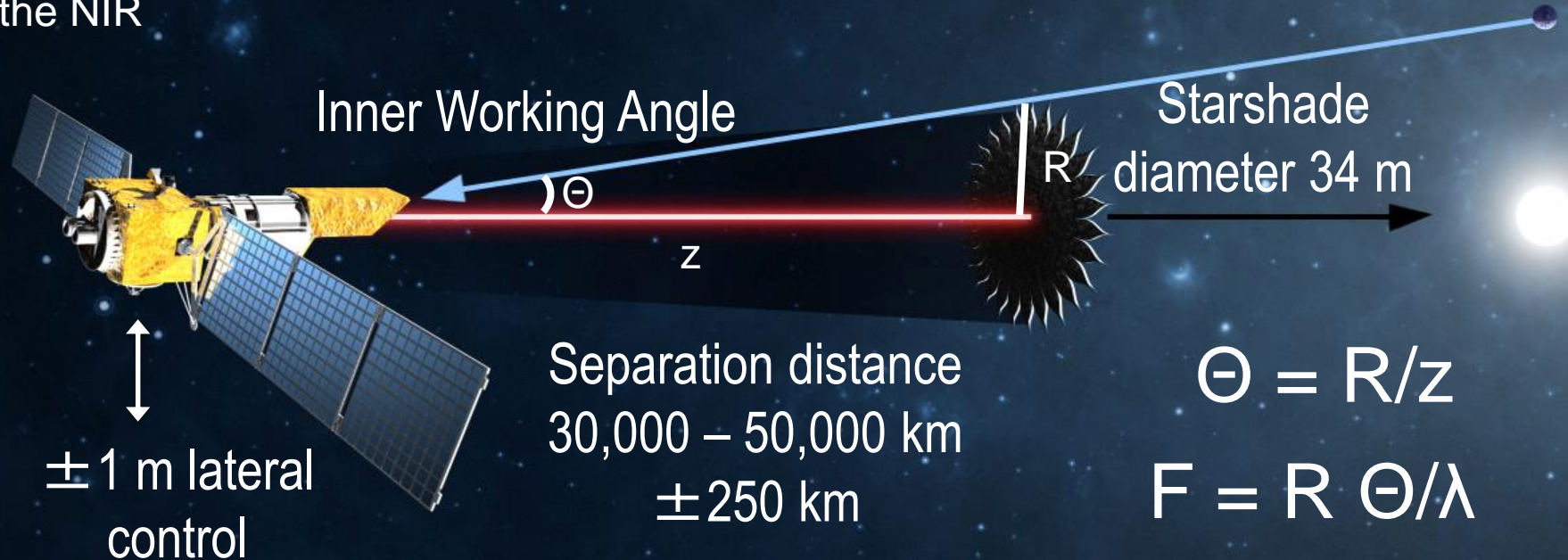
Additional Slides



Allows more exo-Earths
to be characterized in
the NIR

Inner Working Angle (mas)	Starshade Diameter (m)
100	34
73	72
20	100

→ 40-50 exo-Earths



Separation distance
30,000 – 50,000 km
 ± 250 km


$$\Theta = R/z$$

$$F = R \Theta / \lambda$$

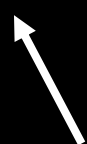
Θ = inner working angle
 R = starshade radius
 z = separation
 λ = wavelength
 F = Fresnel #

Bigger is Better

Mission Concept	Inner Working Angle (mas)	Starshade (m)	Telescope (m)
Rendezvous	100	34	2.4
HabEx	72	72	4
LUVOIR	19	100	15



Allows more exo-Earths
to be characterized in
the NIR



40-50 exo-Earths
in the Habitable Zone